EXHIBIT O

UNITED STATES DISTRICT COURT
EASTERN DISTRICT OF WASHINGTON

CITY OF SPOKANE, a municipal corporation located in the County of Spokane, State of Washington, Plaintiff	)	
v.	)	**Case No. 2:15-cv-00201-SMJ**
MONSANTO COMPANY, SOLUTIA INC., and PHARMACIA CORPORATION, and DOES 1 Defendants	)	

EXPERT REPORT

OF

DR. DAVID L. SUNDING, Ph.D.

November 15, 2019

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I. ASSIGNMENT AND QUALIFICATIONS

1. My name is David L. Sunding. I am the Thomas J. Graff Professor of Natural Resource Economics in the College of Natural Resources at UC Berkeley, where I have been a professor in the Department of Agricultural & Resource Economics since 2002. I served two terms as the chair of my department, and am a founding director of the Berkeley Water Center, an interdisciplinary research center that is a joint venture between the Colleges of Engineering and Natural Resources on the Berkeley campus.

2. I have been asked to estimate the rates of recreational angling and fish consumption along the Spokane River ("River") between the Idaho state line and the confluence with the Columbia River at Lake Roosevelt, and to quantify the population of individuals who consume fish from the Spokane River at high rates. I have also been asked to discuss behavioral characteristics and demographic factors pertinent to exposure of this population of frequent fish consumers to polychlorinated biphenyls ("PCBs").

3. My academic research concerns environmental economics, natural resources, applied econometrics and the economics of regulation. I have won numerous research awards, including grants from the National Science Foundation, the U.S. Environmental Protection Agency ("EPA") and private foundations. I have authored over 100 peer-reviewed journal articles, chapters and studies in the areas of environmental economics, natural resource economics, water resources and the economics of regulation. I teach courses at both the graduate and undergraduate levels in subjects including environmental and resource economics, microeconomic theory, law and economics, risk and water resources.

4. I have testified before Congress on several occasions on matters relating to environmental and resource economics. I have served on expert panels convened by the National Academy of Sciences and EPA's Science Advisory Board. I was instrumental in establishing the National Science Foundation's Engineering Research Center for Reinventing the Nation's Urban Water Infrastructure ("ReNUWIt"), headquartered at Stanford University. During the Clinton Administration, I served as a senior economist at

the President's Council of Economic Advisors, where I had responsibility for the areas of the environment, natural resources, agriculture, and energy. I currently advise the State of California on a variety of matters relating to water quality regulation and water infrastructure investments.

5. Much of my research concerns environmental externalities from economic activities. As part of this research agenda, I have authored papers on the measurement and regulation of environmental health risks. For example, I have conducted research on the subject of environmental health risks from exposure to pesticides and other chemicals in drinking water. I have also written on the impact of environmental health risks on property values and on the economics of defensive expenditures to avoid environmental health risks.

6. I have served as an expert in cases involving groundwater and surface water contamination, natural resource damages, environmental health risk, the use of surveys, water resource management and econometrics. I am a principal in the litigation practice of The Brattle Group, an economic and financial consulting firm based in Boston, MA.

7. I am a member of the American Economic Association, the American Law and Economics Association, the Association of Environmental and Resource Economics and the Econometric Society.

8. I received a Ph.D. in Agricultural & Resource Economics from UC Berkeley in 1989, an M.A. in African Studies from UCLA in 1986 and a B.A. in Economics from Claremont McKenna College in 1983.

9. Appendix A lists my curriculum vitae and a list of cases in which I have testified as an expert at trial or by deposition. The Brattle Group ("Brattle") is compensated at a rate of $650 per hour for my services in this matter. Brattle's compensation is not dependent on the outcome of this litigation or the substance of my opinion.

II. SUMMARY OF OPINIONS

10. The State of Washington Department of Health ("DOH") issues advisories informing anglers about when eating fish from specific waterbodies might impact their health. The plaintiff in this case alleges that the beneficial use of the Spokane River is "impaired" because individuals are advised to limit their consumption of certain fish species at specific locations due to PCB levels in fish. However, recent survey data show that only a small percentage of adults in the Spokane region consume fish caught from the Spokane River, and the number of adults consuming in excess of one meal per (the typical consumption advisory level of the most commonly-consumed fish species) is exceedingly small.

11. The recent survey evidence I analyze also shows that there is no statistically meaningful difference in the rates of fish consumption between those anglers who are aware of fish consumption advisories for the Spokane River and those who are unaware. This finding holds across all levels of consumption, that is, it holds for frequent and infrequent anglers alike. There is thus no empirical evidence that anglers' behavior has been meaningfully constrained by the presence of fish consumption advisories for certain species on various segments of the Spokane River.

12. To address the topics I was asked to consider, I examine multiple data sources collected in studies commissioned by local, state and federal governments trying to understand patterns of angler behavior and fish consumption in the Spokane area. In particular, I analyze micro-data (i.e., individual survey responses) from a 2015 survey conducted by Robinson Research and commissioned by The Spokane River Forum, a non-profit organization that advocates for the protection of the Spokane River, and funded by grants from the Washington State Department of Ecology. This study provides measures of the rates of recreational behaviors, including angling, and attitudes of users of the Spokane River.

13. To estimate fish consumption rates, I also examine micro-data from a second study - a 2013 survey of recreational users and fish consumption on the Upper Columbia River,

including the Spokane River just upstream of the confluence with the Columbia River (i.e., the Spokane Arm of Lake Roosevelt). This second survey was conducted specifically to estimate fish consumption rates as part of the Upper Columbia River Superfund site assessment; the survey was conducted for the U.S. Environmental Protection Agency by Industrial Economics, Inc. ("IEc"). The IEc survey is weighted to control for avidity bias, which is appropriate. I estimate fish consumption rates by reweighting responses from both surveys to reflect the underlying demographics of the counties adjacent to the Spokane River (Spokane, Stevens and Lincoln) as measured by the U.S. Census Bureau's American Community Survey in 2015.

14. Based on my analysis of this site-specific micro-data, I conclude that a large number of people use the Spokane River for recreation. Out of a total regional adult population of 391,000 individuals, I estimate that 82% (320,500) of local residents visit the Spokane River in a typical year for recreational purposes. The most common of these recreational uses are Walking/Running/Biking (61% of adult residents), Picnicking and Scenic Viewing (31%), and Swimming (17%).

15. Only a small percentage of local residents use the Spokane River fishing. I estimate that only 10% of the adult population of Spokane, Stevens and Lincoln counties fish the River in a typical year. This percentage amounts to roughly 40,000 adult individuals. In Spokane County, in which the City of Spokane is located, I estimate that only 7.3% of individuals, or around 25,800 adults, fish the River in a typical year. Most fishing occurs in the Spokane Arm of Lake Roosevelt and Long Lake, both downstream of the Coty of Spokane, and is conducted by boat rather than from piers or the shore.

16. These results provide a snapshot of recreational angling and fish consumption rates among individuals using the Spokane River. National and regional survey data on angling participation provide important context for these cross-sectional results. In particular, it is important to note that recreational angling is experiencing a long-term decline both nationwide and along the Pacific coast, as shown in responses to the National Survey of

Fishing Hunting and Wildlife-Associated Recreation, conducted by the U.S. Fish and Wildlife Service.

17. Among the anglers who report consuming fish from the Spokane River, 99% consume less than one fish meal per week, which is a typical consumption advisory for the most commonly-eaten fish. Among anglers who reside in Stevens, Spokane, and Lincoln Counties and who report consuming fish from the Spokane River, the mean rate of consumption is 4.38 grams per day ("g/day"), which for context is slightly more than the weight of two paper clips, or four plain M&M candies. I find that the 90th percentile level of consumption (i.e., the level of consumption that only 10 percent of anglers who consume fish from the Spokane River are expected to exceed) is 10.10 g/day. The 95th percentile level of consumption among this population is 16.78 g/day, which is less than the weight of two quarters.

18. In Spokane County, where the City of Spokane is located, fish consumption rates are lower than in the region as a whole. Among the anglers who report consuming fish from the Spokane River, the mean rate of fish consumption in Spokane County is 1.21 g/day and the 90^{th} and 95^{th} percentiles of fish consumption are 2.80 g/day and 8.08 g/day respectively.

19. Combining my estimates of the number of Spokane River anglers and their fish consumption rates yields some important insights. Most notably, of the entire adult population of 391,000 of Spokane, Stevens and Lincoln Counties (the area of residence of most Spokane River anglers), only an estimated 460 anglers consume Spokane River-sourced fish in excess of one meal per week. Fewer than 150 of the 460 individuals who consume in excess of one fish meal per week live in the City of Spokane.

20. Only 10% of anglers in the IEc survey report sharing fish with their children. Based on the assumption that children eat on average less than one-third (0.30) of the portion size of the adults who share meals with their children, I estimate the 95th percentile of the fish

consumption rate among the children of anglers to be 4.47 g/day in the Spokane Region as a whole and 2.80 g/day in Spokane County, where the City of Spokane is located.

21. Because the IEc survey instrument asks respondents about their awareness of fish consumption advisories, I can divide the population of anglers into those who are aware of the advisories (42%), and those who are not (58%). I examine the distribution of fish consumption for each of these two sub-populations. Comparing the resulting distributions, I conclude that there is no statistically meaningful difference in the rates of consumption of fish from the Spokane River between those anglers who are aware of advisories and those who are not. This finding suggests that fish consumption advisories do not affect Spokane River anglers' decisions about how much fish to consume.

22. Survey results indicate that most consumers (96%) of Spokane River-sourced fish eat only the fillet, which significantly reduces potential PCB exposure. Only 6% consumers report eating fish skin. Only a single respondent in the IEc survey reports consuming either the eggs or head, and no respondent reports eating the guts of locally caught fish.

23. Beyond these affirmative opinions, I have reviewed the expert report of Dr. Richard DeGrandchamp that was produced by the plaintiffs in this case. Dr. DeGrandchamp's report assumes an average rate of fish consumption among anglers of 42 grams per day, a level far greater than the findings of any relevant fish consumption survey that I have reviewed. Dr. DeGrandchamp does not justify his choice of fish consumption rate; it appears that he has taken the number directly from an outdated risk assessment conducted by the Washington DOH.1 In turn, the Washington DOH risk assessment claims to estimate its fish consumption rate based on two outdated studies (conducted in 1997 and 1998 respectively),[2] however it is not clear how Washington DOH derived this fish

[1] Washington State Department of Health, Evaluation of PCBs, PBDEs and Selected Metals in the Spokane River, Including Long Lake, Spokane, Washington), August 2007. https://www.doh.wa.gov/Portals/1/Documents/Pubs/334-147.pdf

[2] Spokane Regional Health District Assessment/Epidemiology Center, 1998 Fish Consumption Survey: Spokane River, Washington, November 1998.

consumption rate from these studies.3 I estimate from these studies, that the median fish consumption rate is only 14.5 and 6.0 g/day respectively. Since the risks estimates in Dr. DeGrandchamp's report are based on the erroneous consumption estimate of 42 grams per day (a fish consumption rate that appears to have no factual or empirical basis), I find that we cannot draw any conclusions from his report concerning the exposure risks derived from consuming Spokane River fish.

III. BACKGROUND

24. The Spokane Region, which I consider to be the population of Spokane, Lincoln and Stevens counties, has a population of 514,500, based on 2015 Census data. The majority of this population (416,000) lives in the city of Spokane itself. The population of the Spokane Region includes 391,800 adults over the age of 18 and 122,700 children.

25. The Spokane River runs from the outlet of Lake Coeur D'Alene in Idaho to the confluence with the Columbia River at Lake Roosevelt. Lake Roosevelt is a large National Recreational Area formed behind the Grand Coulee Dam. Between these two points the river is dammed in several places, specifically downstream of the city at Little Falls Dam, Long Lake Dam and Nine Mile Dam. The lakes that form behind these dams form popular fishing and recreational lakes. Near downtown Spokane, the river has steep banks and frequent rapids. There is little opportunity to access the river for fishing purposes, however there is a long public trail that runs along the lakefront, including through the popular Riverfront Park in downtown Spokane. Upstream of the City of Spokane, the river forms a well-defined channel and there are some areas with rocky shoals and beaches where it is possible to access the river, however much of this reach runs through developed and industrialized areas which are unattractive for recreation.

Washington State Department of Health, Consumption Patterns of Anglers Who Frequently Fish Lake Roosevelt, September 1997.

[3] The sole piece of information that appears in these studies regarding consumption rates is the single statement that the average rate is 42 meals per year.

26. Spokane was one of the first cities to industrialize in the interior west. Soon after the arrival of the Northern Pacific Railroad in 1882, the river was dammed in multiple places to provide power to milling operations. In 1910, Washington Power built the Little Falls Dam, completely blocking the passage of salmon and steelhead upstream. This led to the elimination of these populations of fish, which members of tribes along the Spokane River traditionally relied on for food. Prior to 1952, Spokane had no wastewater treatment facilities and would dump raw sewage into the river. Even today, overflow events are common in its combined sewer system. In addition to PCBs, the Spokane River also contains high concentrations of heavy metals, resulting from pollution from Lake Coeur D'Alene and from the Bunker Hill Mine and Smelting Complex Superfund site.

27. Recreational fishing takes place on the Spokane River, particularly by boat on several of the lakes formed behind dams along the river, specifically the Spokane Arm of Lake Roosevelt, Long Lake and Nine Mile Reservoir. Fish are stocked in Lake Roosevelt and Long Lake by the Washington Department of Fish and Wildlife ("WDFW"). Where the river is not dammed, it is possible to engage in fly-fishing or other angling along the banks of the river. However, bank fishing along the Spokane River is far less popular than boat fishing. In addition to the Spokane River, there are also numerous other locations in the Spokane region where anglers could choose to recreate. Many of these sites are less polluted and are also frequently stocked with fish by the WDFW. Examples include Lake Pend Oreille, Newman Lake, Hauser Lake, Priest Lake, Loon Lake, Deer Lake and Sullivan Lake.

28. In 1994, The Spokane Regional Health District ("SRHD") first issued notices advising anglers that PCB concentrations in Spokane River fish were of concern. This first notice has since been updated in 1999, 2001, 2003, 2005, 2012 and 2019. These updates often focused on different fish species and different pollutants. Often subsequent advisories were inconsistent with previous ones, becoming either more or less stringent.

29. In 1999, the Washington Departments of Ecology and Health, along with SRHD, issued a fish consumption advisory due to lead; the advisory was based on data collected in the same year. In March 2001, the fish consumption advisory was updated due to elevated PCB concentrations in Spokane River fish. The DOH issued an advisory for Spokane River fish caught between the Washington/Idaho border and Nine Mile Dam. In August 2001, DOH completed an evaluation of cadmium, lead and zinc concentration in Spokane River fish. At this time, the DOH concluded that a public health hazard existed for children and adults, specifically pregnant women, who were exposed to lead through the consumption of whole fish from the Spokane River.

30. In July 2003, SRHD and DOH issued another new advisory that recommended against any consumption of fish between the Idaho border and Upriver Dam. For the reach between Upriver Dam and Nine Mile Dam, DOH advised against eating more than one meal per month of any species. Fish downstream of Nine Mile dam contained lower levels of PCBs and were found safe to eat. The DOH advised cleaning and preparation to reduce exposure to contaminants.[4]

31. In 2005, the DOH updated their advisory again after the Department of Ecology completed a water quality study for the Spokane River that looked at PCBs, polybrominated diphenyl ethers ("PBDEs"), and selected metals in Spokane River fish.[5] As part of their risk evaluation, the DOH noted that they could not identify any subsistence-consuming population of anglers utilizing Long Lake (which is also referred to as Lake Spokane). Another set of fish consumption advisories for the Spokane River

[4] Washington State Department of Health, "Evaluation of PCBs, PBDEs and Selected Metals in the Spokane River, Including Long Lake, Spokane, Washington," August 2007, p. 5. https://www.doh.wa.gov/Portals/1/Documents/Pubs/334-147.pdf

[5]Washington State Department of Health, "Evaluation of Polychlodinated Biphenyls (PCBs) in Fish From Long Lake (a.k.a Lake Spokane)", April 2005.

Spokane Regional Health District and Washington State Department of Health, "Safe Fish Eating Guide," May 2009. https://www.doh.wa.gov/Portals/1/Documents/Pubs/334-123.pdf

was issued in July 2012, based on a fish tissue study conducted in September through October 2009.[6]

32. The most recent fish consumption advisory was published in July 2019[7]. This advisory supersedes all previous advisories. SRHD have produced a poster which illustrates this advisory, which I present in Figure 1. However, this most recent advisory is not currently displayed on their website or anywhere along the Spokane River. The most recent advisory is reflected in a table showing fish consumption advisories for various waterbodies in the State of Washington available on the WDOH website.

33. Table 1 summarizes the current fish consumption advisories along stretches of the Spokane River as they are described on the DOH website. The rows are sorted by fish species from the most to least commonly consumed, based on my analysis of the IEc survey data which I discuss later in Section VII.B. In the most commonly fished reaches of the Spokane River, the Spokane Arm of Lake Roosevelt and Long Lake, the most commonly consumed fish, walleye and rainbow trout, have no fish consumption advisory and an advisory consumption level of about one meal per week, respectively.

34. During a site visit to the Spokane River in September 2019, I found fish consumption advisories to be inconsistently communicated. I visited a number of parks and fishing sites along the Spokane River and I could only find fish consumption advisories signed at two locations. On the section of the river between the Idaho Border and Upriver Dam, near North Harvard Road, I found an outdated fish consumption advisory from 2008 displayed; this outdated advisory is shown in Figure 2. At the Fort Spokane boat ramp, on the Spokane Arm of Lake Roosevelt, I found displayed a fish consumption advisory pertaining to the Upper Columbia River, as shown in Figure 3. I did not observe an up-to-

[6] Washington State Department of Health, "Human Health Evaluation of Contaminants in Upper Columbia River Fish," August 2012. https://www.doh.wa.gov/Portals/1/Documents/Pubs/334-317.pdf

[7] Spokane Regional Health District, "Understanding the Spokane River, A Guide to safer Fishing and Recreation," Poster. 2019.

date fish consumption advisory for the Spokane River anywhere on my trip. At the majority of spots along the Spokane River where locals might go angling, including sites at Long Lake, Nine Mile Reservoir and near the confluence with the Little Spokane River, I could not find any fish consumption advisories posted (although I did see several signs warning visitors, especially those with pets, of the possible presence of toxic blue-green algae). I did not see any fish consumption advisories posted in languages other than English.

Table 1:
Current Fish Consumption Advisories for the Most Common Species Caught from the Spokane River (Meals per Month)

	Spokane Arm – Mouth upriver to Little Falls Dam	Little Falls Pool - Little Falls Dam to Long Lake Dam	Long Lake (Lake Spokane)	Upriver Dam to Nine Mile Dam	Stateline to Upriver Dam[c]
Walleye	No limit	No limit	No limit	No limit	0
Rainbown Trout	4	No limit	4	2	0
Largemouth and Smallmouth Bass[a]	No limit	No limit	No limit	No limit	0
Kokanee	No limit	No limit	No limit	No limit	0
Mountain Whitefish	No limit	No limit	2	1	0
Yellow Perch	No limit	No limit	8	No limit	0
Brown Trout	4	No limit	1	No limit	0
Largescale Sucker	1	4	1	2	0
Northern Pikeminnow[b]	No limit	4	2	No limit	0
Common Carp	No limit	No limit	0	No limit	0

Note: Sorted by mean consumption levels calculated by Brattle (Table 8).
[a]: For children and women of childbearing age, there is also a Statewide advisory of 2 meals per month due to mercury
[b]: For children and women of childbearing age, there is also a Statewide do-not-eat advisory due to mercury
[c]: Catch and release only between Stateline and Upriver Dam
Source: Washington State Department of Health.
https://www.doh.wa.gov/DataandStatisticalReports/HealthDataVisualization/MobileFishAdvisoriesFreshwaterAreasMap

Figure 1:
Current Fish Consumption Advisory Poster
Not Observed Displayed Along the Spokane River

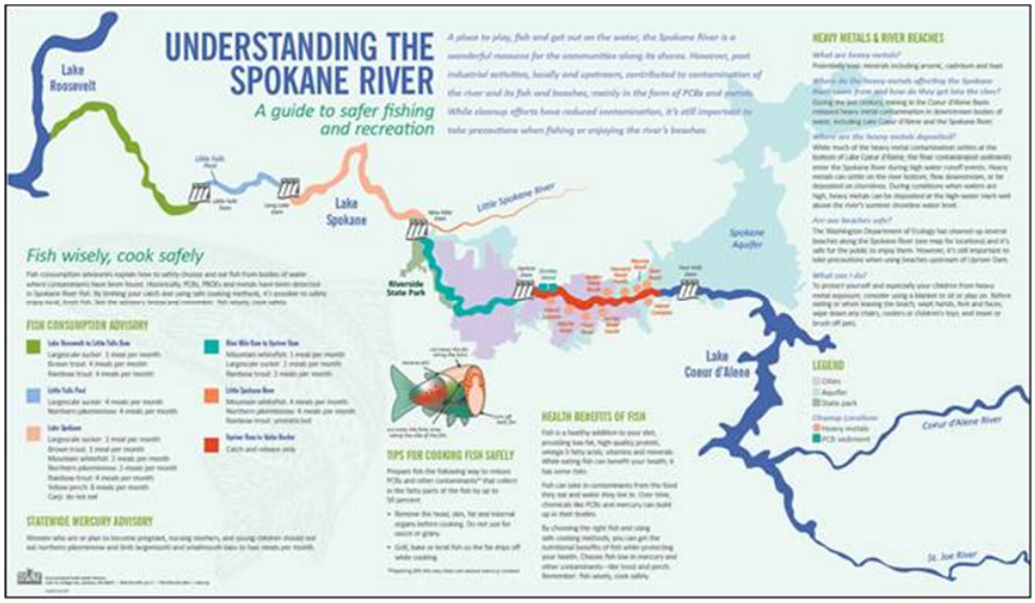
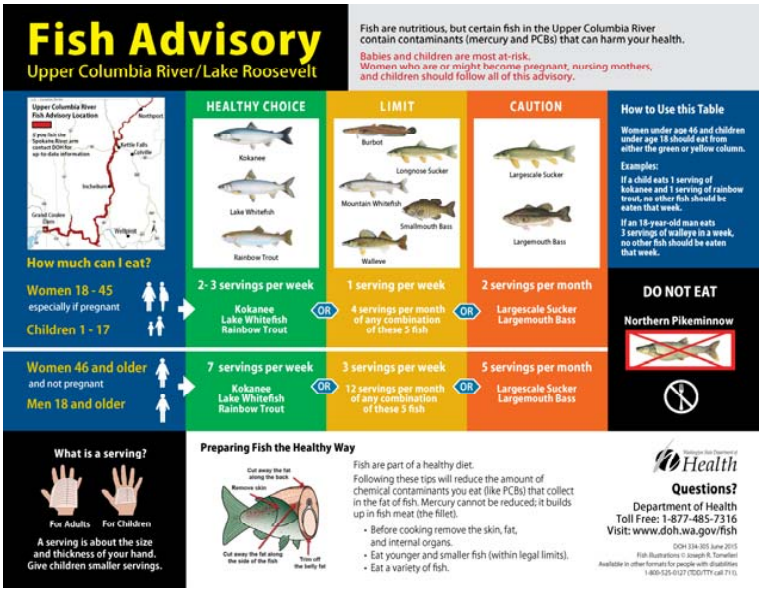


Figure 2:
2008 Fish Consumption Advisory Graphic
Currently Displayed along the Spokane River

Figure 3:
2015 Fish Consumption Advisory Graphic for Upper Columbia River
Currently Displayed on the Spokane Arm of Lake Roosevelt



IV. DATA SOURCES

35. As part of my work in this case, I examine a number of public data sources which I summarize in this section. In particular, I analyze micro-data from two different surveys of recreational angling on the Spokane River. My goal in analyzing the data from these studies is to learn about rates of fish consumption and the most frequent locations of angling along the Spokane River. In addition to my detailed analysis of micro-data from these two surveys, I also review all relevant surveys of fish consumption in the Spokane Region that have been conducted in the past 25 years.

36. The first survey I analyze was conducted by Robinson Research, a Spokane-based survey firm, for the Spokane River Water Quality Forum. The Robinson survey is a random phone survey of individuals from four counties, three in Washington and one in Idaho, who live in zip codes adjacent to the Spokane River. I use the Robinson survey to

identify the number of residents of these counties who 1) choose to visit the Spokane River, 2) choose to fish the Spokane River and 3) consume fish from the Spokane River.

37. The second survey I analyze concerns the consumption of local fish by recreational anglers on the Upper Columbia River, including the Spokane Arm of Lake Roosevelt. This survey was conducted by IEc under contract to the EPA. The survey was released in 2013 and is based on survey data collected in 2010 and 2011. I use the IEc survey to identify rates of Spokane River fish consumption among Spokane area residents.

38. In addition to these two studies, I have also considered a number of other data sources, the results of which I have summarized in Table 2, and each of which I briefly discuss in Section C.

A. ROBINSON RESEARCH, SPOKANE RIVER WATER QUALITY SURVEY

39. The first survey I consider was commissioned by The Spokane River Forum, a non-profit organization that advocates for the protection of the Spokane River and is funded by grants from the Washington State Department of Ecology. Conducted by Robinson Research, the stated goal of the survey was to evaluate public attitudes and perceptions regarding pollution in the Spokane River. The survey was conducted between May and June 2015 and consisted of 600 phone interviews with individuals residing in zip codes adjacent to the Spokane River across three Washington counties (Spokane, Lincoln and Stevens County). The Robinson survey includes responses from zip codes within the Spokane Reservation. The survey also included interviews with individuals from Kootenai County, Idaho; I omit these responses from my analysis.

40. The Robinson survey was stratified to produce an equal number of responses from each county despite each county's different population and demographic profiles. Prior waves of the survey were conducted in 2005 and 2009. The survey asks about the perceptions of pollution along the Spokane River and households' recreational behavior, including fishing and fish consumption.

41. Robinson Research uses a phone call methodology, which is useful in that it is a random sample of the population of interest and does not suffer from problems of avidity bias as is the case in an intercept survey. A weakness of the phone call methodology is that it may lead to sampling bias if the non-response rate is high (12,457 calls were required to produce 600 survey responses) or if specific populations are disproportionately likely to not respond to survey questions. To correct for these biases, I reweight the responses to the Robinson Research survey to reflect the true demographics of the underlying population they are sampling. In my sample reweighting, I consider each individual's county of residence, age and sex.

42. I construct a sample weight $w_{i|c}$ for each individual i with demographic characteristics c where each individual's sample weight is the inverse of their probability of being selected $p_{i|c}$. I estimate this selection probability by taking the ratio of the number of people with that particular set of demographic characteristics in the survey sample n_c^{sample}, to the number of people with that particular set of characteristics in the broader population $n_c^{population}$.

$$w_{i|c} = \frac{1}{p_{i|c}} = \frac{1}{n_c^{sample} / n_c^{population}}$$

43. Using these reweighted responses, I can credibly use various questions from the survey to estimate how many residents of these counties visit the Spokane River, engage in various recreational activities on the Spokane River, fish the Spokane River and consume Spokane River fish.

44. There are some methodological shortcomings in the questions the Robinson survey asks regarding fish consumption rates. Specifically, the survey asks about the number of fish caught for consumption at the household level, rather than individual-level fish consumption. Secondly, the survey does not use a consistent time period when asking about fish consumption and angling behavior (it asks about fish consumption in a `typical month' and recreational behavior in a 'typical year' rather than asking about behavior

over a particular time period). Finally, the survey does not ask about crucial factors that determine fish consumption rates and PCB exposure, such as fish size, portion size, and fish species.

45. As a result of these shortcomings, I do not form my opinion about fish consumption rates from the Spokane River based on the Robinson survey, instead, I use this survey to estimate the rates at which individuals fish the Spokane River and base my estimates of fish consumption rates on the IEc survey I discuss subsequently.

46. However, as a robustness check, I estimate fish consumption rates from the Robinson survey and I find them to be comparable to other local studies. I report these rates in Row [1] of Table 2. In the absence of portion size data, this estimate conservatively assumes that each fish that a household consumes constitutes an 8 oz. meal. Note that these estimated fish consumption rates correspond to the consumption rate for the entire household (including partners and children) rather than just the individual angler. In the Robinson Research survey, household members collectively eat 7.2 g/day (or 0.25 ounces per day, equal to approx. one 8 oz. meal every six weeks) of fish at the 50th percentile and 50.6 g/day at the 95th percentile (or 1.8 ounces per day, equal to three meals per month).

B. INDUSTRIAL ECONOMICS, UPPER COLUMBIA RIVER SURVEY

47. The second survey I consider is a state-of-the-art fish consumption survey commissioned jointly by the U.S. Environmental Protection Agency and the National Park Service on the reach of the Upper Columbia River stretching from the Grand Coulee Dam to the U.S.-Canada border. Industrial Economics, Inc. conducted the survey through an on-site intercept design. This survey was conducted specifically to estimate fish consumption rates as part of the Upper Columbia River Superfund site assessment. The survey sampled at boating sites, campsites and day-use sites along the river between October 2010 and September 2011. The survey also attempted to collect data from shore anglers,

however this effort was abandoned after IEc could not find a sufficient number of shore anglers to produce statistically valid results.

48. The survey instrument collected demographic data including sex, age and zip code of residence. The survey instrument did not directly ask whether respondent was a member of a Native American tribe. However, some respondents did report residing in zip codes within the Spokane Reservation. Spokane Reservation residents account for 1.1% of the observations (14/1271) in the IEc data from the Spokane region; Spokane Reservation residents are 0.4% of the total population of the Spokane region (2,094/514,500). [8]

49. All consumers were asked in the intercept survey to recall the rate at which they had consumed fish over the past twelve months. A subset of consumers who reported consuming fish at an elevated rate were also given the option of completing a three-month mail-in diary of consumption of Lake Roosevelt sourced fish. The survey was rigorously pre-tested and the data entry validated to assure its quality.

50. The survey area of the IEc study included the Spokane Arm of Lake Roosevelt, which is the portion of the Spokane River just upstream of its confluence with the Columbia River. My main analysis uses all UCR data collected by the IEc researchers; in Appendix Table 6, I also display the results of my analysis using only those responses collected from fishing on the Spokane Arm. Using the broader set of survey responses increases the precision of my estimates of fish consumption. As seen in Appendix Table 6, the fish consumption estimates based on the more geographically limited data (i.e., just those from trips to the Spokane Arm) are not statistically distinguishable from those I discuss in the main body of my report.

51. Using the 2,109 individual responses to the intercept surveys collected by the IEc researchers, I calculate fish consumption rates as follows: first I sub-set individuals by

[8] Spokane Reservation population is taken from the Spokane Tribe of Indians' 2016 Annual Report. Accessed at: https://www.bia.gov/sites/bia.gov/files/Spokane.AR_.2016%20to%202016.Nar%20%20508%20Comp.pdf

their response to Question D2 "Do you eat fish from the Upper Columbia River?" to determine the subset of respondents who consume fish from the UCR. Next, I sum the responses to Question D4 "About how many meals of [species] have you eaten over the past 12 months?" over the five different fish species which the survey asks about (walleye, bass, kokanee, trout and other). This calculation gives me the total number of meals from the UCR. Individuals who responded to D2 but did not respond to D3 were assumed not to have eaten any of that particular fish in the past year. Next, I look at responses to Question D9 in which participants are shown a figure with illustrative portion sizes on it and asked which serving size most closely resembles their typical meal. Following the methodology of the survey, I code the responses of typical portion sizes as being 4 oz., 6 oz., 8 oz., 10 oz., and 12 oz. respectively for consumption relative to the example serving sizes.[9] Multiplying the 'typical portion size' by the 'total number of meals' and then converting the response to ounces and dividing by the number of days in the year.

52. IEc constructed survey weights which account for avidity bias. The survey weights also account for the different likelihood of being intercepted on particular visit days, and at different sites along the river, as well as different likelihood of group intercepts and of being surveyed within a particular group. I replicated the survey weights that are described in the original IEc study and I use these weights in all my subsequent estimates.

53. Note that the responses to "other" mostly consist of perch (30% of responses in the "other" category), burbot (36%), and triploid (11%). Only one respondent (1.5%) reports catching a northern pike, the only fish with a do not eat advisory in the Upper Columbia River. One respondent reports eating carp. No respondents report catching suckerfish which has a one meal per month advisory limit in the Upper Columbia River.

[9] If a respondent reported eating more than zero meals but did not respond to the portion size question, I assume a typical portion size of 8 oz. I also tried an alternative approach of imputing portion sizes from a regression which yielded similar results.

54. Most fish were caught on boating trips. Only 15% of boating trips lasted over 24 hours meaning that Lake Roosevelt is primarily a day-use facility. The vast majority of boat trips on the Spokane Arm of Lake Roosevelt left from either Porcupine Bay or Fort Spokane. A total of 10% of all fish caught were from the Spokane Arm of Lake Roosevelt. Walleye, which do not have an advisory in the Spokane Arm, are the most popular fish consumed from this reach of the Spokane River. 36% of fish in the survey were caught downstream in reaches of Lake Roosevelt downstream of the confluence with the Spokane River (Areas 6, 7).

55. Households who consumed more than one meal per month of fish were given the option of completing an additional diary survey. Respondents were incentivized to complete this survey with a $50 payment for every month they returned a diary. The diary records the date, species, source, parts consumed and meal size for every meal the respondents consumed, as well as whether the meal was shared with a child and the portion size of the child. I use the same method as previously described to estimate the portion sizes for respondents to the diary survey. Table 2 compares the distribution of fish consumption rates between diary survey respondents and intercept survey respondents. The fish consumption rates recorded in the diary survey are significantly higher than those in the intercept survey. This larger fish consumption rate reflects the fact that the diary survey was only completed by a subset of individuals who are significantly higher fish consumers. Because the responses to the diary survey are not a representative subset of the population, my estimates of fish consumption rates focus on only the responses to the intercept survey.

C. OTHER DATA SOURCES

56. Table 2 reports various studies that report fish consumption rates in the area surrounding the Spokane River. Rows [1]-[3] of this table report the numbers for the Robinson Research and Industrial Economics survey discussed above.

57. Rows [4] and [5] report the estimated fish consumption rate from a survey administered to residents of the Colville Reservation by Westat. The results of this survey are

presented in the report Upper Columbia River Site Remedial Investigation and Feasibility Study Tribal Consumption and Resource Use published in June 2012. The survey was sponsored by the EPA as part of the Upper Columbia River Superfund site investigation.

58. The mean fish consumption rate among residents of the Colville Reservation is estimated to be 20.2 g/day. However, this estimate is not directly relevant for my analysis. Much of the fish consumption of the Colville Reservation residents are of wild salmon caught from a large salmon run on the Okanogan River. The Spokane River has no remaining anadromous salmon due to the presence of Grand Coulee Dam, which blocks fish passage downstream of the Spokane River. Excluding salmon from the estimated fish consumption rate of Colville tribal members reduces the mean fish consumption rate to 13.3 g/day.

59. Rows [6] and [7] report the findings of two outdated studies of fish consumption rates in the Spokane region. Row [6] shows the results from a 1997 study conducted by the Spokane Regional Health Department. The study included a mail survey of anglers within Spokane and a focus groups of two ethnic minority groups within the Spokane River. Furthermore, the public report from this study is extremely brief (10 pages), and I have not been able to find any detailed documentation of the survey methodology or instrument adopted in this study. The mail survey had an extremely low response rate; only 70 responses were received from 32,702 surveys mailed to fishing license holders. Based on the figure in page 5 of this report, I estimate the median fish consumption rate to be 6 g/day. Note that I approximate this number from the graphic because the study did not report any summary statistics.

60. The Spokane Regional Health Department survey also conducted focus groups targeted at Russian, Laotian and Hmong communities who were thought to consume fish at an elevated rate. However, the study could not identify any Hmong community members who fished the Spokane River and the focus groups for Russian and Laotian communities only had “approximately thirty” and six attendees, respectively, including children. The populations of these communities in the Spokane Area are exceedingly small. Based on

Census data, the population of Hmong, Laotian and Russian individuals in Spokane County was 141, 364 and 6927 individuals respectively in 2010.

61. Row [7] shows results from a survey conducted in 1994 and 1995 by the DOH. This study was an intercept survey of anglers on Lake Roosevelt. The study reported that anglers consume on average 42 meals per year, which equates to around 25.2 g/day. No individuals in this study reported consuming sturgeon, sucker or whitefish. For several reasons, however, this study has been superseded by the more recent IEc study. The DOH study does stratify its sampling across times and locations along the lake, however unlike the IEc study, estimates from the DOH study do not adjust for the different rates at which sampling locations are frequented. The DOH study also does not correct for avidity bias, again providing a point of contrast with the IEc study. The DOH study also has a substantially smaller sample size than the IEc survey (348 vs 846 fish consumers).

62. Rows [8] and [9] present estimates from the U.S. Center for Disease Control's National Health and Nutrition Examination Survey ("NHANES"). NHANES is a continuously updated survey collecting data on the health and nutritional status of the U.S. population. This survey is the largest and most comprehensive dietary study conducted in the United States. The NHANES study estimates fish consumption rates using the NCI and the EPA method.[10] Because this study reports consumption rates among the entire U.S. population of freshwater and estuarine fish from all sources (including non-locally caught and store-

[10] See, Estimated Fish Consumption Rates for the U.S. Population and Selected Subpopulations (NHANES 2003-2010), April 2014. p. 21-30. For a detailed discussion of the NCI and EPA methods. Also, see p. 2:

"In the mid-2000s, the National Cancer Institute (NCI) developed a statistical methodology to estimate usual intake of episodically consumed foods. This method, known as the NCI Method, has been published and statistical programs are available on NCI's web site. There are other methods that have been developed to estimate the distribution of usual intake of episodically consumed foods. However, the NCI Method is preferred because it accounts for days without consumption; distinguishes within-person from between-person variation; allows for the correlation between the probability of consumption and the consumption-day amount; and can use covariate data to better predict usual intake… To get estimates in a reasonable time, EPA created a program, hereinafter referred to as the EPA Method, which approximates the results from the NCI Method."

bought fish), this study provides an extremely conservative upper bound on the average amount of fish consumed from any specific locality, such as the Spokane River. NHANES reports that among adult residents of the Inland West11, the median rate of consumption from all sources is 4.3 g/day and the 95th percentile of fish consumption is 26.2 g/day. Among residents that are neither Hispanic nor white or black, a sub-population that contains many minorities who consume fish at elevated levels, NHANES find a median rate of consumption of 12.6 g/day and a 95th percentile of 62.3 g/day.

[11] The inland west is defined as all non-coastal counties California, Oregon, Washington, Alaska, and Hawaii and all counties in New Mexico, Colorado, Wyoming, Montana, Idaho, Utah Arizona and Nevada.

Table 2: Estimates of Fish Consumption Rates from Prior Surveys in the Spokane Region

Publication Year		Dept./Author	Population of Interest	Species	Region/Source	Mean	50th	95th	99th	# of Fish Consumption Responses	Survey Method	Sampling Method and Selection
2015	[1]	Robinson Research for the Spokane River Forum	Adults who consume Spokane River fish living in Spokane, Lincoln, and Stevens Counties	Locally-caught fish	Spokane River	12.1*	7.2*	50.6*	108.5*	141	Typical year consumption	Telephone interviews stratified county
2013	[2]	Industrial Economics for DOI	Anglers who consume UCR fish	Locally-caught fish	Upper Columbia River inc. Spokane arm of Lake Roosevelt	4.5*	1.8*	15.1*	30.1*	836	12-month recall interviews	Intercept Survey Stratified by type of day, month, and season
2013	[3]	Industrial Economics for DOI	Anglers who consume >10 UCR fish meals per year	Locally-caught fish	Upper Columbia River inc. Spokane arm of Lake Roosevelt	19.5*	14.5*	47.0*	65.1*	415	3-month diary	Subsample of respondents reporting "High Fish Consumption"
2012	[4]	Westat for EPA Region 10	Residents of the Colville Reservation	Locally-caught fish	Local area surrounding Colville Tribes	20.2	3.7	64.6	206.3	1,139	12-month recall interviews	Dwelling visits stratified by age group
2012	[5]	Westat for EPA Region 10	Residents of the Colville Reservation	Locally-caught fish excl. salmon	Local area surrounding Colville Tribes	13.3	0.0	41.0	144.2	1,139	12-month recall interviews	Dwelling visits stratified by age group
1998	[6]	Spokane Regional Health District	Angler who consume Spokane River fish	Locally-caught fish	Spokane River	0	6.0*	60.3*	60.9*	70	12-month recall interviews	Mail survey to Spokane County fishing license holders
1997	[7]	Washington State Department of Health	Angler who consume Lake Roosevelt fish	Locally-caught fish	Lake Roosevelt	25.4*	14.5*	62.2*	62.3*	348	12-month recall interviews	Intercept survey stratified by lake region and time of day
2014	[8]	EPA (NHANES)	All adults	All Sources, freshwater or estuarine fish	Inland West	0	4.3	26.3	51.6	3,705	24-hour dietary recall	NHANES multistage probability sampling design
2014	[9]	EPA (NHANES)	All adults, not Hispanic, White, or Black	All Sources, freshwater or estuarine fish	U.S.	0	12.6	62.3	114.7	1,476	24-hour dietary recall	NHANES multistage probability sampling design

Notes and sources:

*: Estimated based on average portion sizes of 220 grams.

[1]: Robinson Research, Spokane River Water Quality Survey, Spokane, Lincoln, & Stevens Counties, May 2015.

[2]: Industrial Economics for U.S. DOI, Recreational Consumption and Resource Use Survey for the Upper Columbia River Site Human Health Risk Assessment and Remedial Investigation/Feasibility Study: Data Summary Report, May 2013.

[3]: Industrial Economics for U.S. DOI, Recreational Consumption and Resource Use Survey for the Upper Columbia River Site Human Health Risk Assessment and Remedial Investigation/Feasibility Study: Data Summary Report, May 2013.

[4]: Westat for EPA Region 10, Upper Columbia River Site Remedial Investigation and Feasibility Study Tribal Consumption and Resource Use Study, June 2012. Brattle Calculations using Microdata.

[5]: Westat for EPA Region 10, Upper Columbia River Site Remedial Investigation and Feasibility Study Tribal Consumption and Resource Use Study, June 2012. Brattle Calculations using Microdata.

[6]: Spokane Regional Health District Assessment/Epidemiology Center, 1998 Fish Consumption Survey: Spokane River, Washington, November 1998.

[7]: Washington State Department of Health, Consumption Patterns of Anglers Who Frequently Fish Lake Roosevelt, September 1997.

[8]: EPA, Estimated Fish Consumption Rates for the U.S. Population and Selected Subpopulations (NHANES 2003-2010), April 2014.

[9]: EPA, Estimated Fish Consumption Rates for the U.S. Population and Selected Subpopulations (NHANES 2003-2010), April 2014.

V. VISITATION AND ANGLING RATES

63. In this section, I present my estimates of participation rates in recreational activities on the Spokane River, including angling and local fish consumption. The results in this section are based on responses given in the Robinson Research survey. However, I have re-weighted the responses in the survey to better reflect the underlying demographics of the population in the three counties of interest as described in Section IV.A.

A. ON THE SPOKANE RIVER

64. Question 5 of the Robinson Research survey asked respondents "In a typical year, how many times do you visit the Spokane River?" 81.8% of respondents, or a total population of 320,500 adults visited the Spokane River at least once in a typical year. The first column of Table 3 reports the distribution of these visits.

65. To estimate the share of individuals who engage in any particular activity on the Spokane River, I use the responses to Question 6 of the Robinson Research. This question was asked respondents "What activities best describe how you interact with the Spokane River?" The question was left open-ended and asked of all respondents who reported visiting the Spokane River at least once in a typical year. Responses are reported in the first row of Table 3. The most common of these recreational uses are Walking/Running/Biking (61.1% of residents), Picnicking and Scenic Viewing (31.4%), and Swimming (16.6%).

66. However, the vast majority of these visitors do not fish in the Spokane River. Based on my reweighting of Question 6 of the Robinson Research survey, I estimate that only 10% of the adult population of Spokane, Stevens and Lincoln counties fish regularly from the River. This amounts to approximately 40,000 adult individuals.

67. Note that the construction of Question 5 and Question 6 of the Robinson Survey do not allow me to break out the number of visits per activity because respondents are not specifically asked this. However, if I assume that individuals dedicate an equal number of

visits to each activity they report, I can approximate the number of visits per activity by dividing the total number of visits by the number of activities reported. My estimates of the number of visits per activity are broken out by quantile in Rows [2]-[6] of Table 3. Using this approach, I estimate that on average local residents make fishing related visits to the Spokane River four times per year, and that the median resident fishes the Spokane River less than once per year, and at the 95th percentile resident fishes the fewer than ten times per year.

68. In Table 4, I break down the rates at which residents of visit, fish and eat fish from the Spokane River based on their demographic groups. Comparing Columns [2] and [3], men fish the Spokane River at about three times the rate of women (15.4% vs 5.3%) and they consume fish at more than twice the rate of women (11.0% vs 4.7%). Older residents are more likely to fish the Spokane River (13.9 % for adults aged 50-65 vs 7.0% for adults aged 18-30). However, younger residents are more likely to consume fish from the Spokane River (8.5 % for adults aged 50-65 vs 10.4% for adults aged 18-30). Rates of angling and fish eating are significantly higher in rural Stevens and Lincoln counties than in urban Spokane County. Adults fish at 36.7 and 33.3% rates in Stevens and Lincoln counties compared to 7.3% in Spokane County. Adults consume fish at 33.2 and 32.1% rates in Stevens and Lincoln counties compared to 5.0% in Spokane.

B. ON DIFFERENT REACHES OF THE SPOKANE RIVER

69. In Table 5 I estimate on which reach of the Spokane River users typically recreate. The first row of Table 4 estimates the average number of households who visit different reaches of the river. These estimates are based on responses to Question 7 of the Robinson Research survey. This question asked respondents "In which of the following areas do you most often interact with the Spokane River?" Respondents were given options as to which reaches they specified, however were allowed to give multiple responses.

70. Similarly, Question 35 of the Robinson Research survey asked respondents who reported catching fish from the Spokane River "Where do you generally catch fish". Note that the

response rate for this question was extremely low, only 77 respondents answered the question. Therefore, there is a high degree of uncertainty about the reported estimates for angling rates along different Spokane River reaches.

71. The Spokane River travels inside the limits of the City Spokane on the reach of the river between Nine Mile Dam and Upriver Dam (specifically from near the Downriver Golf Course to Upriver Dam) and also for a short distance on the reach between Upriver Dam and State Line (only between Upriver Dam to upstream end of Felts Field Airport).

72. In terms of recreational visits to the Spokane River, which do not necessarily involve angling or consumption, I find that 62.8% of trips to the Spokane River are along the reach that includes downtown Spokane between Upriver Dam and Nine Mile Dam. 14.6% of visits take place on the reach between Upriver Dam and Stateline where there is a 'Do Not Eat' advisory in place. 16.6% of visits take place downstream of Spokane, between the Spokane Arm of Lake Roosevelt and Nine Mile Dam.

73. In terms of angling, respondents typically catch fish at locations further downstream from the City of Spokane, either at Long Lake (49.2%) or Lake Roosevelt (34.8%). Fewer than 15% of anglers fish the reaches between Nine Mile Dam and State Line, which lie on reaches of the river that may be within the City Limits of Spokane, and many of these anglers likely are fishing at Nine Mile Dam Reservoir, which is outside city limits. Only 4.0% of Spokane River anglers report visiting the reach of river between State Line and Upriver Dam, where DOH has a 'Do Not Eat' advisory on the river.

Table 3: Estimated Number of Visitors by Activity

Quantile	All Visits	Walking, Running, Biking	Picnicing, Senic View	Fishing	Swimming	Motorized Boating	Non-Motorized Boating	Going to Beach	Inner Tubing	Other
	Number of Households Engaged in Activity									
	320,500 [308,100, 332,900] *(81.8%)*	239,500 [223,800, 255,100] *(61.1%)*	123,100 [108,100, 138,000] *(31.4%)*	40,000 [30,300, 49,700] *(10.2%)*	64,900 [52,900, 76,800] *(16.6%)*	26,900 [18,800, 35,100] *(6.9%)*	43,100 [33,100, 53,200] *(11.0%)*	11,000 [5,700, 16,300] *(2.8%)*	16,600 [10,100, 23,100] *(4.2%)*	9,000 [4,200, 13,800] *(2.3%)*
	Number of Annual Visits Per Activity									
Mean	30.0 [24.2, 35.8]	11.0 [8.6, 13.7]	5.0 [3.1, 6.9]	4.0 [1.9, 5.2]	6.0 [3.9, 7.7]	3.0 [1.1, 4.3]	4.0 [2.2, 5.2]	1.0 [0.5, 1.9]	1.0 [0.8, 2.1]	2.0 [0.4, 2.9]
50%	5.0 [3.7, 6.3]	1.0 [0.6, 1.4]	0.0 [0.0, 0.0]	0.0 [0.0, 0.0]	0.0 [0.0, 0.0]	0.0 [0.0, 0.0]	0.0 [0.0, 0.0]	0.0 [0.0, 0.0]	0.0 [0.0, 0.0]	0.0 [0.0, 0.0]
90%	60.0 [14.7, 105.3]	26.0 [5.0, 47.0]	5.0 [2.1, 7.9]	1.0 [0.0, 3.1]	10.0 [0.0, 21.3]	0.0 [0.0, 0.4]	2.0 [0.0, 9.3]	0.0 [0.0, 2.1]	0.0 [0.0, 4.5]	0.0 [0.0, 0.0]
95%	200.0 [117.9, 282.1]	60.0 [21.1, 98.9]	15.0 [0.9, 29.1]	10.0 [0.0, 26.4]	40.0 [8.7, 71.3]	5.0 [0.0, 12.3]	21.0 [0.0, 51.5]	0.0 [0.0, 24.9]	0.0 [0.0, 31.3]	0.0 [0.0, 0.0]
99%	365.0 [355.8, 365.0]	182.5 [152.2, 212.8]	182.5 [105.1, 259.9]	182.5 [74.8, 290.2]	132.5 [60.1, 204.9]	175.0 [30.3, 319.7]	100.0 [41.9, 158.1]	50.0 [4.6, 95.4]	50.0 [14.2, 85.8]	75.0 [0.0, 188.5]

Source and notes: This table calculates the number of visitors to the Spokane River who engage in different recreational activities and their average number of visits per activity each year. Estimates based on responses to questions to Q5 and Q6 of the Robinson Research (2015) Spokane River Water Quality Survey. Where respondents identified more than one activity, I make the assumption that individuals divide the total number of trips equally between all of those activities. Populations are reweighted to reflect populations in the Census Bureau (2015) American Community Survey data. Square brackets calculate the 95% confidence intervals of each estimate.

Table 4: Visitation, Angling and Consumption Behavior by Sub-Population

		All	Male	Female	Female 18-50	Age 18-30	Age 30-50	Age 50-65	Age 65-100	Stevens County	Spokane County	Lincoln County
All adult residents	[1]	391,800	191,000	200,800	111,200	90,000	133,000	101,300	67,400	31,300	352,400	8,100
Residents who **visit** the Spokane River	[2]	319,500 [302300, 332000] *(81.5%)*	158,400 [147200, 166500] *(82.9%)*	161,100 [151000, 170100] *(80.2%)*	98,800 [89900, 104300] *(88.8%)*	84,900 [71800, 90000] *(94.3%)*	114,400 [107400, 123300] *(86.0%)*	78,400 [72200, 84000] *(77.4%)*	41,900 [38000, 47400] *(62.2%)*	27,600 [25600, 29400] *(88.2%)*	284,900 [268600, 298000] *(80.8%)*	7,000 [6500, 7500] *(86.4%)*
Residents who **fish** the Spokane River	[3]	40,000 [28500, 52900] *(10.2%)*	29,400 [20700, 39400] *(15.4%)*	10,600 [7200, 15200] *(5.3%)*	4,600 [2100, 6800] *(4.1%)*	6,300 [0, 11900] *(7.0%)*	13,400 [7700, 19800] *(10.1%)*	14,100 [10000, 19200] *(13.9%)*	6,300 [4300, 8600] *(9.3%)*	11,500 [7900, 14100] *(36.7%)*	25,800 [15600, 35700] *(7.3%)*	2,700 [2100, 3300] *(33.3%)*
Residents who **consume fish** from the Spokane River	[4]	30,600 [19700, 44900] *(7.8%)*	21,100 [13200, 31700] *(11.0%)*	9,500 [4800, 16700] *(4.7%)*	5,300 [1800, 12400] *(4.8%)*	9,400 [0, 19700] *(10.4%)*	8,900 [4300, 15200] *(6.7%)*	8,600 [5600, 11800] *(8.5%)*	3,700 [2400, 5200] *(5.5%)*	10,400 [6900, 12800] *(33.2%)*	17,600 [7600, 30900] *(5.0%)*	2,600 [1800, 3300] *(32.1%)*

Source and notes: This table calculates the number of residents, Spokane River visitors, Spokane River anglers, and Spokane River fish consumers within each of the different demographic groups that are controlled for in the statistical model, specifically, the sex, age and county of origin. Choices are estimated based on responses to questions to Q5 and Q34 of the Robinson Research (2015) Spokane River Water Quality Survey. Populations are reweighted to reflect populations in the Census Bureau (2015) American Community Survey data. Round brackets calculate the percent of the total population of that demographic in that group.

Table 5: Visitation and Angling Use by River Reach

	Spokane Arm - Lake Roosevelt to Long Lake Dam	Long Lake/ Lake Spokane	Nine Mile Dam to Upriver Dam	Upriver Dam to Stateline	Stateline to Lake Coeur D'alene
Share of **residental users** who **visit** this reach	8.9% [5.7%, 14.5%]	7.7% [5.6%, 9.8%]	62.8% [54.5%, 69.8%]	14.6% [9.5%, 20.7%]	6.0% [1.8%, 11.4%]
Share of **anglers** who **fish** this reach	49.2% [15.0%, 67.0%]	34.8% [18.6%, 64.9%]	10.8% [1.0%, 34.1%]	4.0% [0.0%, 26.3%]	1.1% [0.0%, 3.9%]

Source and notes:

This table calculates the number and share of recreational visitors and anglers on five different reaches of the Spokane River among residents of three Washington counties adjacent to the Spokane River (Spokane, Stevens and Lincoln Counties). Although this survey included angling locations in Idaho, I exclude all responses from Idaho residents. Choices are estimated based on responses to questions to Q6 and Q35 of the Robinson Research (2015) Spokane River Water Quality Survey. Populations are reweighted to reflect populations in the Census Bureau (2015) American Community Survey data. Round brackets calculate the percent of the total population of that demographic in that group. Standard errors in square brackets are calculated by bootstrap.

C. NATIONAL AND STATEWIDE TRENDS

74. To estimate trends in national angling patterns, the U. S. Fish and Wildlife Bureau conducts National Survey of Fishing, Hunting, and Wildlife-Associated Recreation ("FHWAR") every five years. The most recent report is from 2016. The data provide a nationally representative look at angling participation rates, angling expenditures, and overall angler behavior and demographics.

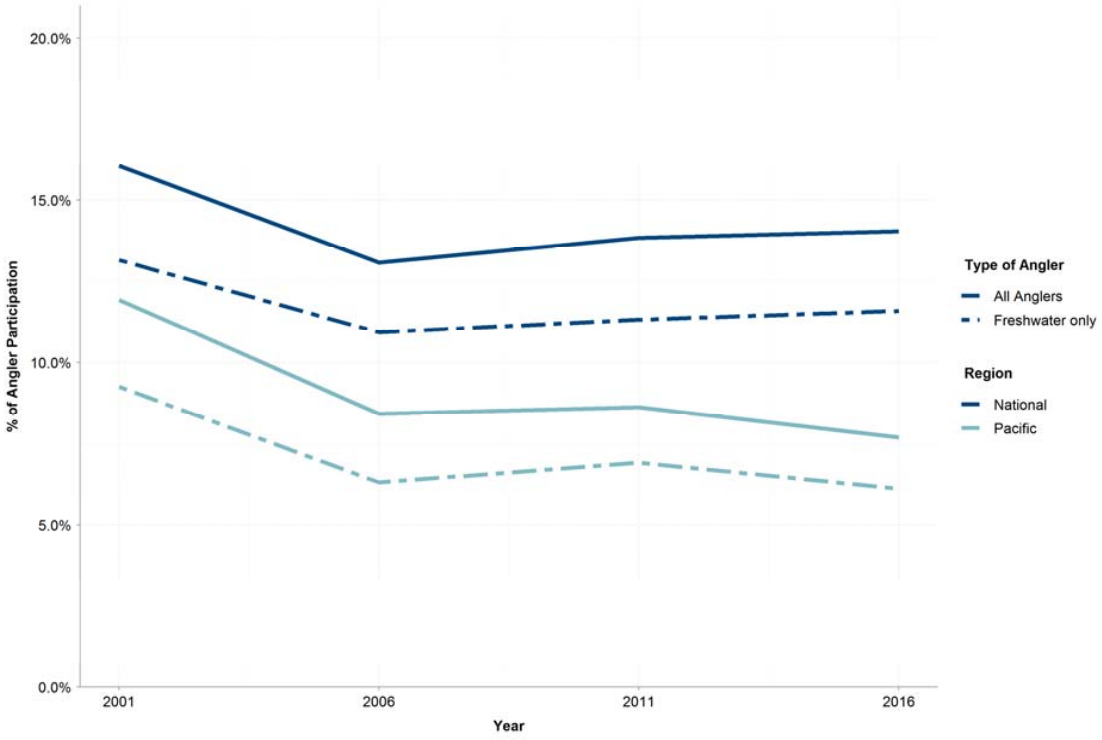
75. In Figure 4 below, I graph angler participation nationally, and for the Pacific Census region (this region includes Washington, Oregon and California). The figure shows that angling rates have decreased significantly since 2001 at all levels.12 Additionally, the Pacific census region has significantly fewer individuals involved in angling. In 2016 angling rates nationally were at 14% and 8% within the Pacific census region.

76. In order to look more closely at angler behavior that is more relevant to Spokane, I calculate angler participation rates for freshwater fishing, also seen in Figure 4 below. Freshwater fishing rates are somewhat lower than for all anglers. There has been a similar decline in rates of freshwater angling.[13]

[12] The Pacific Census region includes the following states: Alaska, California, Hawaii, Nevada, Oregon, and Washington. In 2016, the FHWAR data no longer reported statistics at the state level.

[13] The nationwide long term decline in recreational angling has been discussed in popular media. For instance, a 2018 article in the Minneapolis Star-Tribune noted that "[t]he average millennial picks up a smartphone 45 times a day…" The article goes on note that millenials' number one reason for going outdoors is to exercise. Second is a venue to socialize. Third is to camp or hike. Quoting John Arms, a recreation industry analyst, the article notes that "'In one U.S. Fish and Wildlife Service study, hunting and fishing don't even show up in the top 10 reasons millennials go outdoors.' The cliff's edge upon which hunting, fishing and wildlife management are perched is weaker than many suspect, he said. 'We'll go from 8 or 9 percent of the nation's population who hunted and fished in 1980 to 3 percent in 2025.'" Accessed at http://www.startribune.com/anderson-will-millennials-step-up-as-hunting-and-angling-continues-decline/468820183/

Figure 4: Angler Participation by Region and Type of Angler



Source: FHWAR.

VI. EMPIRICAL APPROACH TO ESTIMATING FISH CONSUMPTION RATES IN THE SPOKANE RIVER

77. Figure 5 summarizes my approach to estimating the rates of fish consumption rates and other behaviors among the populations of Spokane, Stevens, and Lincoln counties. I describe this approach further in Appendix C.

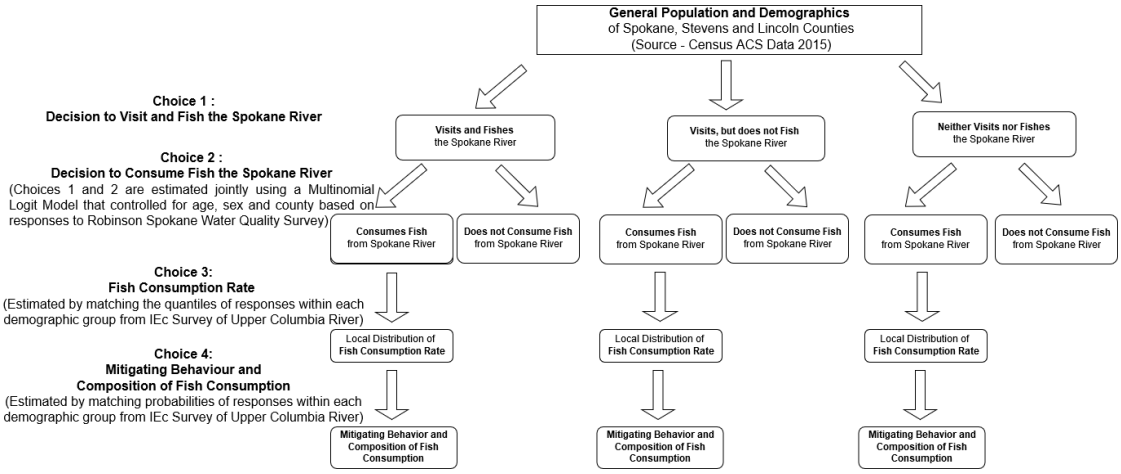
78. To predict these behaviors, I classify their behavior by two choices they make: Based on responses to Questions 5 and 6 of the Robinson Research survey whether a respondent either 1) fish the Spokane River or, 2) visit the Spokane River but do not fish or 3) do not visit the Spokane River. Next, based on responses to Question 34 of Robinson Research, I classify whether and secondly by whether they 1) consume fish from the Spokane River or 2) do not.

79. Next, I estimate a multinomial logit mode which describes the probability with which an individual will select into each of these six behavioral groups as a function of their demographic characteristics. The model uses age, county of residence and sex as demographic factors to explain participation rates. Based on 2015 population demographics from U.S. Census Bureau's American Community Survey, I use the multinomial logit model to predict the number of individuals who engage in visitation, angling and fish consumption from the Spokane River within each demographic group, and in the population as a whole.

80. Using responses from the IEc study, I estimate every quantile of the rate of fish consumption in 1% increments between 0% and 100% within each demographic group (consisting of a different permutation of sex, age and county of residence). Then, I calculate the distribution of total fish consumption by summing up the rates of fish consumption over the all different demographic groups, each weighted by their respective populations.

81. I use a similar approach to estimate fish consumption rate among individuals who share fish with children, or who are aware or unaware of fish consumption advisories. Data on child sharing and any mitigating behavior such as awareness of fish consumption advisories or the parts of fish consumed, are also obtained from the IEc study. I calculate a 95% confidence interval for my estimates using a bootstrap method over the all the steps of the estimation process. The logic of the model is summarized in Figure 5 below.

Figure 5: Outline of Model to Estimate Spokane River Fish Consumption



Source and notes:

This diagram summarizes the model I estimate to characterize angling behavior on the Spokane River. I start with population demographics from the 2015 American Community Survey. I use responses to Q5, Q6 and Q35 of the Robinson Research survey to estimate a multinomial logit model that predicts the rate at which individuals visit, fish, and consume fish from the Spokane River. Among individuals who consume fish from the Spokane River, I estimate their fish consumption rates based on responses to part D of the IEc Survey. My analysis assumes that rates of fish consumption are similar among anglers on the Spokane River as on Lake Roosevelt within each demographic control group. Responses from the Upper Columbia River Survey are also used to characterize other behaviors that affect individual exposure, such as sharing fish with children, awareness, and responsiveness to advisories and methods of fish preparation.

VII. RATES OF FISH CONSUMPTION FROM THE SPOKANE RIVER

82. In this section, I present my estimates of fish consumption rates for the Spokane River. These estimates are based on the portion sizes and meal frequencies from the IEc study.

A. QUANTILES OF FISH CONSUMPTION RATES

83.

84. Table 6 presents my baseline estimates of fish consumption rates from the Spokane River. The first row of

85. Table 6 displays the consumption rate among the entire adult population of Spokane, Lincoln and Stevens counties. Row [2] restricts the population to only adults who visit the Spokane River. Row [3] restricts the population to only adults who are anglers on the Spokane River. Row [4] restricts the population to only adults who consume fish from the Spokane River.

86. Among the population as a whole, the average fish consumption rate is only 0.34 g/day and the median and 95th percentile of fish consumption are 0.00 and 0.93 g/day respectively. However, among the 10% of the population who regularly fish the Spokane River, consumption rates average of 2.16 g/day, or a median and 95th percentile of 0.00 or 10.10 g/day respectively. Among individuals who regularly consume fish from the Spokane River, the average fish consumption rate is 4.38 g/day and the median and 95th percentiles are 1.86 and 16.78 g/day respectively. Figure 6 displays a histogram of fish consumption. Key quantiles are shown in dashed lines.

Table 6: Fish Consumption Rates

				Fish consumption rate among sub-population (g/day)			
				Quantiles			
	Population	(%)	Mean	50%	90%	95%	99%
All adult residents [1]	391,800	100.0%	0.34 [0.24, 0.48]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.93 [0.00, 2.36]	8.70 [5.97, 11.18]
Residents who **visit** the Spokane River [2]	319,500	81.5%	0.42 [0.29, 0.59]	0.00 [0.00, 0.00]	0.00 [0.00, 0.93]	1.55 [0.25, 3.11]	9.94 [7.77, 14.55]
Residents who **fish** the Spokane River [3]	40,000	10.2%	2.16 [1.54, 2.92]	0.00 [0.00, 0.09]	6.21 [3.73, 9.32]	10.10 [7.92, 15.53]	24.85 [20.97, 37.28]
Residents who **consume fish** from the Spokane River [4]	30,600	7.8%	4.38 [3.42, 5.44]	1.86 [1.10, 2.49]	10.10 [8.08, 15.53]	16.78 [12.43, 21.75]	38.84 [27.77, 46.60]

Source and notes:

This table calculates the mean fish consumption rate and quantiles of the fish consumption rate among different subsets of the adult population of three Washington counties adjacent to the Spokane River. Estimates are calculated based on the population demographics in Table 3 and responses to part D of the Industrial Economics (2013) Upper Columbia River Survey. The model assumes that rates of fish consumption are similar among anglers on the Spokane River as on Lake Roosevelt within each demographic control group. Standard Errors in square brackets are calculated by bootstrap.

[1]: In this row fish consumption rates are calculated among the entire population of Spokane, Lincoln and Stevens Counties.

[2]: In this row, fish consumption rates are calculated among the subset of the population of these counties who visit the Spokane River in a typical year.

[3]: In this row, fish consumption rates are calculated among the subset of the population who fish from the Spokane River.

[4]: In this row, fish consumption rates are calculated among the subset of the population who consume fish from the Spokane River in a typical month.

87. Table 7 stratifies by various demographic characteristics the fish consumption rates among anglers that are reported in the third row of

88. Table 6. Rates of participation in angling on the Spokane River is far higher in the more rural Stevens and Lincoln counties, at 36.8% and 33.3% respectively (Rows [3] and [4]), compared to 7.3% in Spokane County (Row [2]), where the City of Spokane is located. Fish consumption rates are also far higher in Stevens and Lincoln counties than in Spokane. The average fish consumption rate among anglers in Stevens and Lincoln is 4.03 g/day and 3.21 g/day compared to 1.21 g/day in Spokane.

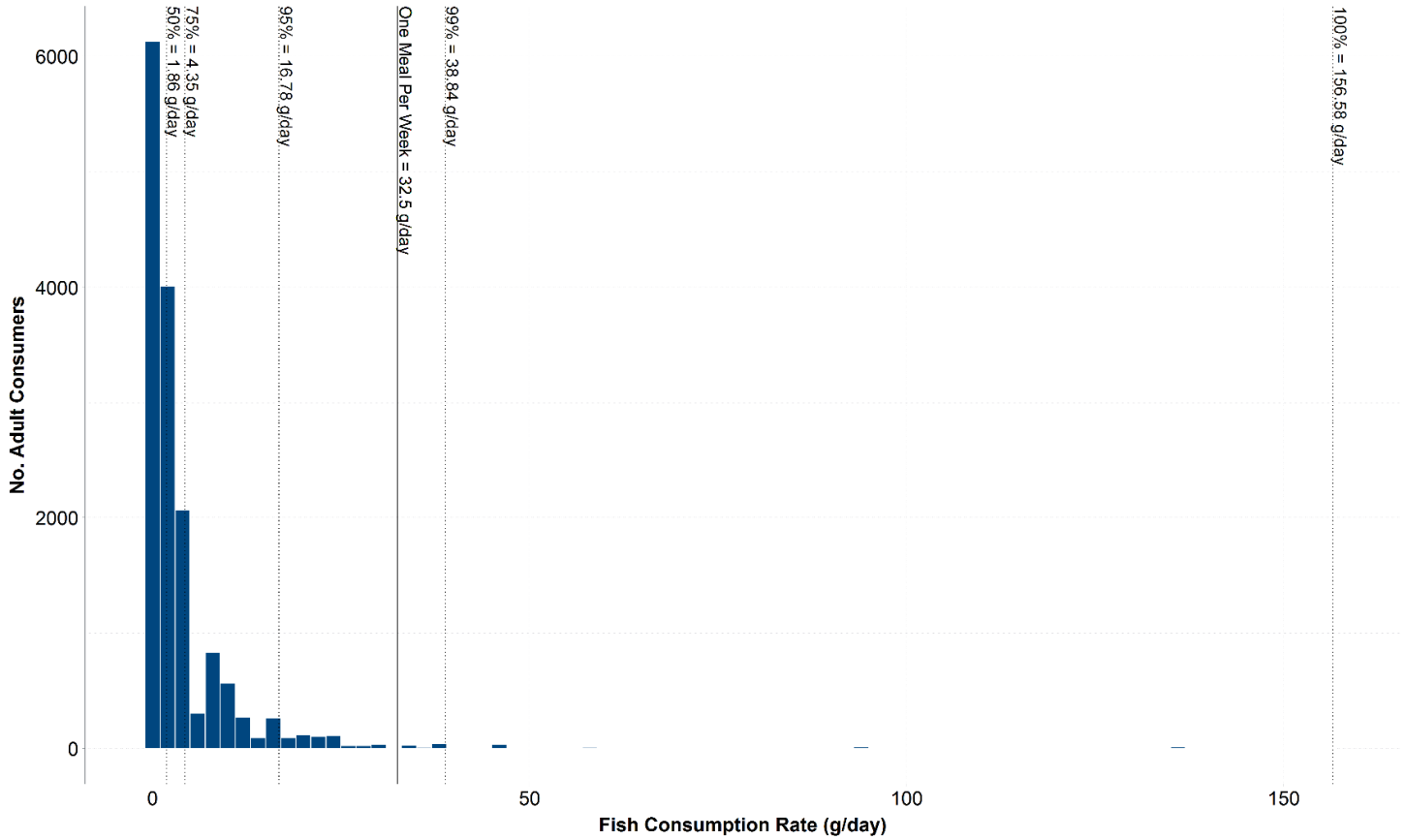
89. Finally, in Rows [5] through [8] of Table 7 we observe the fish consumption rates are highest among oldest and youngest populations in the survey. Anglers aged from 18 to 30 or from 66 to 100 respectively consume on average 3.16 g/day and 2.31 g/day of fish, compared to 31 to 50 and 51 to 65-year-olds, who consume only 1.73 g/day and 2.05 g/day respectively. However, participation rates are higher among the middle-aged cohort compared to the young cohort.

90. In Rows [9] and [10] of Table 7, we observe that there are almost three times as many male anglers as there are female (29,400 vs 10,600). And that males consume fish at a far higher rate than females, at a mean rate of 2.41 g/day for men compared to 1.46 g/day for women. This pattern also holds among the highest fish consumers in Spokane, at the 95th percentile men consume 11.18 g/day compared 6.21 g/day for women. In Row [11] shows that women of childbearing age have an average fish consumption rate of 1.99 g/day.

91. In the last two columns of Table 7, I calculate the number of anglers who consume in excess of one fish meal per week, the level of a fish consumption advisory which is typical for some fish on the Spokane River. I estimate that the total population in the Spokane Region consuming in excess of one fish meal per week is 460. Half of these individuals (230) live in Stevens County. Only 150 individuals live in Spokane County, implying that fewer than 150 individuals who consume more in excess of one fish people per week live in the City of Spokane.

92. The majority of these individuals consuming in excess of one fish meal per week are male (270/460). The majority of these individuals consuming in excess of one fish meal per week are aged between 30 and 65 (370/460). These individual account for just over one percent (1.15%) of all local adult Spokane River anglers. Note that my estimates of the number of high consuming individuals is for all reaches of the Spokane River and for all species of fish, and it does not necessarily imply that this is the number of individuals who are exceeding local fish consumption advisories for PCBs, because these individuals could be consuming fish from a reach of the river with no local PCB related consumption advisory.

Figure 6: Distribution of Fish Consumption Rates



Source and notes:

Estimated following methodology. Each bar is 2g/day wide. Dashed line indicates consumption level of one fishmeal per week (32.5 g/day).

Table 7: Fish Consumption Rates among Anglers by Demographic Group

Group		Population	(% of total pop)	Fish consumption rates among anglers (g/day) Mean	Quantiles 50%	90%	95%	99%	Consume > 1 fish meal per week	(% of consumer pop)
Total	[1]	40,000 [28,500, 52,900]	*10.2% [7.3% , 13.5%]*	2.16 [1.54, 2.92]	0.00 [0.00, 0.09]	6.21 [3.73, 9.32]	10.10 [7.92, 15.53]	24.85 [20.97, 37.28]	460 [230, 760]	*1.15% [0.58%, 1.90%]*
By county										
Spokane	[2]	25,800 [15,600, 35,700]	*7.3% [4.4% , 10.1%]*	1.21 [0.49, 2.03]	0.00 [0.00, 0.00]	2.80 [0.91, 7.95]	8.08 [2.26, 9.99]	18.64 [9.94, 23.35]	150 [30, 240]	*0.58% [0.13%, 0.95%]*
Stevens	[3]	11,500 [7,900, 14,100]	*36.7% [25.3% , 45.0%]*	4.03 [2.79, 5.17]	1.24 [0.00, 1.86]	10.10 [7.46, 14.96]	18.02 [11.68, 23.61]	46.60 [24.85, 47.88]	230 [80, 540]	*2.00% [0.67%, 4.67%]*
Lincoln	[4]	2,700 [2,100, 3,300]	*33.3% [25.9% , 40.9%]*	3.20 [1.60, 5.37]	0.47 [0.00, 1.86]	6.21 [3.73, 15.53]	10.56 [4.66, 33.55]	37.28 [13.01, 130.49]	80 [10, 220]	*2.96% [0.33%, 8.13%]*
By age										
18-30	[5]	6,300 [0, 11,900]	*7.0% [0.0% , 13.2%]*	3.14 [1.74, 4.77]	0.93 [0.47, 156.58]	9.32 [4.35, 156.58]	10.10 [8.08, 156.58]	24.23 [10.10, 156.58]	30 [0, 100]	*0.48% [0.00%, 1.54%]*
31-50	[6]	13,400 [7,700, 19,800]	*10.1% [5.8% , 14.9%]*	1.74 [0.74, 2.73]	0.00 [0.00, 0.31]	2.80 [1.24, 7.92]	7.92 [2.80, 14.79]	33.55 [15.43, 46.60]	220 [60, 490]	*1.64% [0.46%, 3.68%]*
51-65	[7]	14,100 [10,000, 19,200]	*13.9% [9.9% , 19.0%]*	2.04 [1.34, 3.20]	0.00 [0.00, 0.00]	5.13 [3.70, 11.18]	11.18 [7.77, 18.64]	24.85 [18.64, 37.28]	150 [40, 240]	*1.06% [0.28%, 1.68%]*
66-100	[8]	6,300 [4,300, 8,600]	*9.3% [6.4% , 12.7%]*	2.33 [1.34, 4.03]	0.00 [0.00, 0.93]	7.46 [3.73, 14.57]	12.43 [7.46, 20.97]	26.10 [18.02, 38.84]	60 [20, 220]	*0.95% [0.36%, 3.44%]*
By sex										
Male	[9]	29,400 [20,700, 39,400]	*15.4% [10.8% , 20.6%]*	2.41 [1.70, 3.50]	0.00 [0.00, 0.93]	7.46 [4.35, 9.94]	11.18 [8.13, 16.22]	24.76 [21.73, 37.28]	270 [120, 460]	*0.92% [0.41%, 1.55%]*
Female	[10]	10,600 [7,200, 15,200]	*5.3% [3.6% , 7.5%]*	1.46 [0.55, 2.46]	0.00 [0.00, 0.00]	3.73 [0.45, 5.13]	6.21 [2.48, 10.10]	25.48 [10.10, 46.60]	190 [40, 430]	*1.79% [0.39%, 4.08%]*
Female 18-50	[11]	4,600 [2,100, 6,800]	*4.1% [1.9% , 6.1%]*	1.99 [0.67, 4.24]	0.00 [0.00, 0.61]	4.35 [0.93, 10.10]	10.10 [2.49, 29.48]	46.60 [6.21, 46.60]	120 [0, 330]	*2.61% [0.00%, 7.09%]*

Source and notes:

This table calculates the mean fish consumption rate and quantiles of Spokane River fish consumption rates among different demographic groups based on county of residence, age, and sex. Estimates are calculated based on the population demographics in Table 3 and responses to part D of the Industrial Economics (2013) Upper Columbia River Survey. The model assumes that rates of fish consumption are similar among anglers on the Spokane River as on Lake Roosevelt within each demographic control group. Standard Errors in square brackets are calculated by bootstrap.

[1]: In this row fish consumption rates are calculated among all adult fish consumers in the study area

[2]-[4]: In these rows, fish consumption rates are within each county adjacent to the Spokane River

[5]-[8]: In these rows, fish consumption rates are calculated within different adult age groups

[9]-[11]: In these rows, fish consumption rates are calculated within each sex and for female of child-bearing age

B. SPECIES PREFERENCE

93. In Table 8, I show the distribution of species of consumed by anglers in my model. I find that walleye and rainbow trout are the most popularly consumed fish, respectively accounting for 51.4% and 33.0% of catch. This amounts to a mean fish consumption rate of 1.11 g/day of walleye and 0.71 g/day of rainbow trout. Bass, kokanee and other fish species have a mean fish consumption rate of less than 0.15 g/day. The median fish consumption rate is zero for all fish species. At the 95th percentile fish consumption rate for both walleye and rainbow trout is 4.66 g/day. The 95th percentile for bass is 0.58 g/day and the 95th percentile for kokanee and other fish is zero.

94. Note that this species preference is based on the distribution of species found in Lake Roosevelt, rather than in some of the other lakes (such as Long Lake or Nine Mile Reservoir). There are some differences in the distribution of species present in these lakes, however, these differences are primarily among species that are not typically caught and consumed, such as suckers and carp.

95. Although there is a fish consumption advisory for walleye and bass on Lake Roosevelt, there is not a similar advisory on the Spokane River, except for the 'catch and release only' reach between Stateline and Upriver Dam. The advisory for rainbow trout may be more or less restrictive on Lake Roosevelt compared to the Spokane River depending on the characteristics of the angler and the reach of the Spokane River.

Table 8: Species Preference and Fish Consumption Quantiles among Residents who Consume Spokane River Fish

				Fish Consumption Rates among Anglers (g/day) Quantiles			
Species			Mean	50%	90%	95%	99%
Walleye	[1]	51.4% [45.9%, 57.3%]	1.11 [0.71, 1.67]	0.00 [0.00, 0.00]	1.86 [1.24, 4.39]	4.66 [3.26, 9.32]	15.53 [12.33, 18.74]
Rainbow Trout	[2]	33.0% [27.8%, 37.6%]	0.71 [0.43, 1.10]	0.00 [0.00, 0.00]	2.80 [1.55, 3.73]	4.66 [3.11, 7.77]	12.43 [9.32, 14.91]
Bass	[3]	7.2% [4.5%, 10.6%]	0.15 [0.07, 0.31]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.58 [0.00, 0.93]	2.49 [1.37, 4.66]
Kokane	[4]	6.2% [4.2%, 8.0%]	0.13 [0.06, 0.23]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 1.24]	3.73 [1.86, 6.21]
Other	[5]	2.2% [1.0%, 4.0%]	0.05 [0.02, 0.12]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.78 [0.31, 1.24]
All	[6]	100% [100%,100%]	2.16 [1.54, 2.92]	0.00 [0.00, 0.09]	6.21 [3.73, 9.32]	10.10 [7.92, 15.53]	24.85 [20.97, 37.28]

Source and notes:

This table calculates the average species composition of fish consumed from the Spokane River in three adjacent Washington counties. Estimates are calculated based on the population demographics in Table 3 and responses to part D of the Industrial Economics (2013) Upper Columbia River Survey. Fish are categorized into groups as presented in the original survey. This table also calculates the quantiles of the fish consumption rate for specific species on the Spokane River. The model assumes that rates of species-specific fish consumption are similar among anglers on the Spokane River as on Lake Roosevelt within each demographic control group. Standard Errors in square brackets are calculated by bootstrap. Fish consumption quantile estimates are projected onto the population demographics reported in Table 3.

C. SHARING WITH CHILDREN

96. In Table 9, I report fish consumption quantiles for anglers who share fish with their children, and I estimate children's fish consumption rates based on these responses. The surveys I study do not ask specific questions about child consumption and portion size, but rather simply ask respondents how many children the share their catch with. Following NHANES, I assume that a child's portion is equivalent to 0.3 of the responding adults' portion size.[14]

97. Only 2.0% of residents of Spokane, Stevens and Lincoln counties share their Spokane River-caught fish with children. Comparing the consumption rates in Row [2] of Table 9

[14] The ratio of the adult to children median fish consumption rate for all finfish is reported in U.S. Environmental Protection Agency. "Estimated Fish Consumption Rates for the U.S. Population and Selected Subpopulations (NHANES 2003-2010)." EPA-820-R-14-002. April 2014. Tables 11b and 22a.

to those in Row [1], anglers that share with children consume an almost identical amount of Spokane River fish to the general population. The 95th quantile for adults that share with children is 14.91 g/day in row 2, compared to the 10.10 g/day reported in Row [1]. Using the 0.3 adjustment to portion size, I obtain an estimate of child consumption. This multiplication results in a weighted mean of 0.97 g/day and a 95th quantile of 4.47 g/day. The resulting 95th consumption quantile for children is significantly below the recommended one serving per week.

98. Within Spokane County, where the City of Spokane is located, residents share fish with their children at a lower rate (0.9%) than in the region as a whole (2.0%). Anglers who share fish with their children also consume fish at a lower rate than in the region as a whole.

Table 9: Inferred Child Fish Consumption Rate

				Quantiles of Fish Consumption (g/day)			
		% of Population	Mean	50%	90%	95%	99%
Spokane, Stevens and Lincoln Counties							
All adult residents who fish the Spokane River	[1]	*10.2%* *[7.26%, 13.51%]*	2.16 [1.54, 2.92]	0.00 [0.00, 0.09]	6.21 [3.73, 9.32]	10.10 [7.92, 15.53]	24.85 [20.97, 37.28]
Anglers who **share with children**	[2]	*2.0%* *[1.09%, 2.78%]*	3.22 [2.12, 4.32]	0.00 [0.00, 0.00]	9.32 [4.61, 12.43]	14.91 [9.32, 22.03]	37.28 [24.23, 69.08]
Inferred rate: **angler's children** who cosume fish	[3]		0.97 [0.64, 1.30]	0.00 [0.00, 0.00]	2.80 [1.38, 3.73]	4.47 [2.80, 6.61]	11.18 [7.27, 20.72]
Spokane County Only							
All adult residents who fish the Spokane River	[4]	*7.3%* *[4.43%, 10.14%]*	1.21 [0.49, 2.03]	0.00 [0.00, 0.00]	2.80 [0.91, 7.95]	8.08 [2.26, 9.99]	18.64 [9.94, 23.35]
Anglers who **share with children**	[5]	*0.9%* *[0.36%, 2.06%]*	1.64 [0.73, 2.91]	0.00 [0.00, 0.00]	4.35 [0.93, 9.94]	9.32 [2.80, 21.75]	21.75 [9.94, 33.54]
Inferred rate: **angler's children** who cosume fish	[6]		0.49 [0.22, 0.87]	0.00 [0.00, 0.00]	1.31 [0.28, 2.98]	2.80 [0.84, 6.52]	6.52 [2.98, 10.06]

Source and notes:

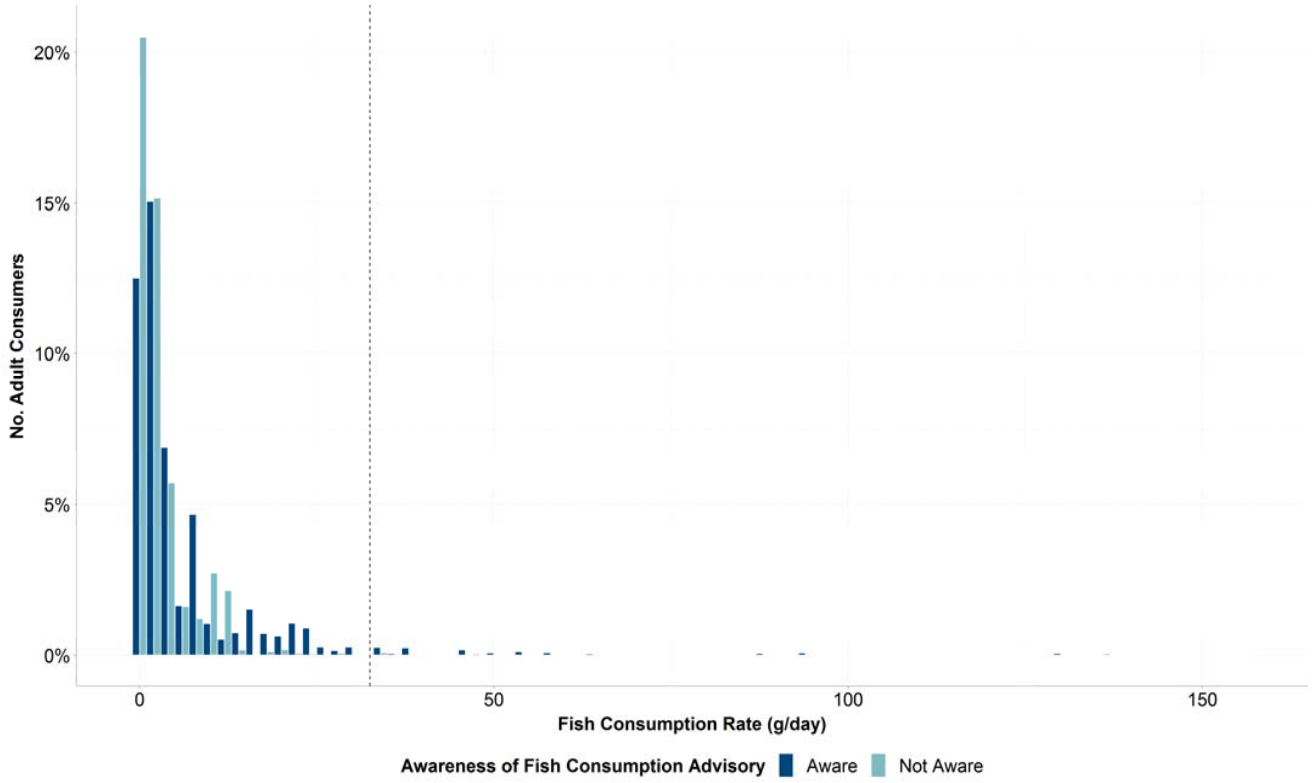
This table calculates the number of adults who share fish with children in three Washington counties adjacent to the Spokane River, as well as the child's mean fish consumption rate and quantiles of the fish consumption rate. The estimates of the number of adults who share their fish with children are calculated from a logit model based on responses to question D10 in the Industrial Economics (2013) Upper Columbia River Survey. These responses are projected onto the population demographics reported in Table 3. Child fish consumption rates are estimated based on a child to adult consumption ratio of 0.3 to 1. These ratios are based on the national NHANES database. This model assumes that rates of fish consumption are similar among anglers on the Spokane River as on Lake Roosevelt within each demographic control group. Standard Errors in square brackets are calculated by bootstrap

VIII. BEHAVIORAL AND DEMOGRAPHIC CONSIDERATIONS FOR PCB EXPOSURE

A. AWARENESS OF FISH CONSUMPTION ADVISORIES

99. As I previously discussed, fish consumption advisories do not appear to be posted at many fishing spots along the Spokane River. Indeed, based on the Upper Columbia River survey, 54.5% of anglers are aware of fish consumption advisories. This allows me to test whether there is a difference in fish consumption rates between the anglers who are aware advisories and those who are not**.** The data in Table 10 demonstrate that anglers who are aware of fish consumption advisories in fact eat more fish than those who are not, however this difference is not statistically significant at the mean or the 50th, 90th or 95th percentiles. This finding leads me to conclude that there is no evidence that fish consumption advisories suppress fish consumption rates.

Figure 7:
Distribution of Fish Consumption Rates by Awareness of Fish Consumption Advisories



Source and notes:

Dashed line indicates consumption rate of one fish-meal per week

Table 10: Fish Consumption Rates by Awareness of Fish Consumption Advisories

Sub-Population		Population	(%)	Mean	Fish Consumption Rates among Anglers (g/day) Quantiles 50%	90%	95%	99%
All residents who fish the Spokane River	[1]	40,000 [28,459, 52,923]	5.1% [3.6% , 6.8%]	2.16 [1.54, 2.92]	0.00 [0.00, 0.09]	6.21 [3.73, 9.32]	10.10 [7.92, 15.53]	24.85 [20.97, 37.28]
Angling residents who are **aware** of fish consumption advisories	[2]	21,900 [16,266, 27,188]	5.5% [4.1% , 6.8%]	2.88 [2.11, 3.98]	0.00 [0.00, 0.93]	7.92 [5.59, 14.06]	16.16 [11.55, 21.75]	33.55 [25.38, 46.60]
Angling residents who are **not aware** of fish consumption advisories	[3]	18,100 [11,884, 25,362]	4.7% [3.1% , 6.6%]	1.56 [0.99, 2.19]	0.00 [0.00, 0.00]	4.97 [2.47, 9.32]	9.32 [4.97, 11.18]	12.43 [11.12, 23.30]

Sources and Notes:

This table calculates the mean fish consumption rate and quantiles of the fish consumption rate among anglers on the Spokane River residing in three Washington Counties. Estimates are calculated based on the population demographics in Table 3and responses to part D of the Industrial Economics (2013) Upper Columbia River Survey. Each estimate is based on using a different subset of the data from the IEc study. The model assumes that rates of fish consumption are similar among anglers on the Spokane River as on Lake Roosevelt within each demographic control group. Standard Errors in square brackets are calculated by bootstrap.

[1]: In this row fish consumption rates are calculated based on responses by from all anglers.

[2]: In this row fish consumption rates are calculated based on responses by anglers who are aware of fish consumption advisories.

[3]: In this row fish consumption rates are calculated based on responses by anglers who are not aware of fish consumption advisories

B. PARTS OF FISH CONSUMED

100. Among individuals who report consuming fish within the last 12 months from the Upper Columbia River, Table 11 estimates the share of individuals who consume different parts of the fish. All individuals in the sample reported consuming the fillet of the fish. Only 6% of individuals consume the skin and fewer than 1% of individuals reported consuming fish eggs or head. Zero respondents reported consuming the guts of locally caught fish.

Table 11: Parts of Spokane River Fish Typically Consumed

Part	Share of Consumers
Fillet	100.0% [100.0%, 100.0%]
Skin	6.0% [4.3%, 7.7%]
Eggs	0.6% [0.0%, 1.1%]
Head	0.7% [0.1%, 1.2%]
Guts	0.0% [0.0%, 0.0%]

Sources and Notes:
This table calculates the share of respondents to the IEc survey who report consuming different parts of fish. Responses are weighted by the individual weights in the IEc report. The 95% confidence interval is reported in square brackets and calculated assuming a binomial distribution.

IX. RESPONSE TO DEGRANDCHAMP REPORT

101. Dr. DeGrandchamp attempts to estimate the health risks from PCB exposure as a result of fish consumption in Book 3 of his expert report. His results depend entirely on an assumed rate of fish consumption that has not been empirically estimated. However, he does not calculate in his report the rate at which anglers consume fish, the crucial component of estimating hypothetical risks due to PCB exposure from the consumption of Spokane River Fish. Instead of carefully calculating fish consumption rates as I have

done in my analysis, DeGrandchamp assumes a fish consumption rate of 42 g/day. This number is taken from an outdated 2007 risk assessment produced by the DOH.[15] The DOH risk assessment does not justify this fish consumption rate, however, it does cite two fish consumption studies as the basis for this number.[16] I have previously discussed these studies are reported in Section IV.C and in Table 2, Rows [8] and [9]. In my discussion I highlighted a number of limitations of these studies in terms of age, methodology and documentation. The methodological limitations I highlighted included small sample sizes, low response rates, and failure to account for avidity bias. Furthermore the 42 g/day number appears to be based on an incorrect interpretation a key result of the in the 1997 Lake Roosevelt Fish Consumption Study. In this study the average consumption rate is reported as 42.2 fish meals per year (not g/day) and when converted to the appropriate units (assuming an 8oz portion size) this quantity amounts to only 25.4 g/day.

102. These flaws render the fish consumption rate of 42g/day used by DeGrandchamp, and all of the subsequent analysis on which it depends unreliable. The data used in my estimate of the fish consumption rate employs more recent data, and carefully implements the correct statistical methods that allow the survey microdata to be used for inference on the population of interest.

X. CONCLUSIONS

103. I quantify fish consumption rates along the Spokane River using two primary sources: recreational activity participation rates from the Robinson Research survey to estimate rates of fishing, and fish consumption rates based on the IEc survey of fish consumption rates on Lake Roosevelt. I reweight the responses to both of these surveys based on

[15] See, Evaluation of PCBs, PBDEs and Selected Metals in the Spokane River, Including Long Lake, Spokane, Washington. p. 16.

[16] Washington State Department of Health. "Consumption Patterns of Anglers Who Frequently Fish Lake Roosevelt." September 1997.

Spokane Regional Health District. "1998 Fish Consumption Survey: Spokane River, Washington." November 1998.

Census demographic data to reflect the true underlying populations of Spokane, Lincoln and Stevens counties. Based on this analysis, I conclude that the population of individuals who fish in the Spokane River is around forty thousand. Of this number, less than ten percent fish the Spokane River more than once per year, and less than less eighty percent, or roughly thirty thousand individuals, report consuming fish caught in the River. And of this number of anglers who sometimes consume the fish they catch, only an exceedingly small group (460 individuals) consume more than one Spokane River-sourced fish meal per week. This group of most frequent consumers accounts for less than one tenth of one percent of the population of the Spokane region.

104. The weighted average fish consumption rate among anglers on the Spokane River is 2.16 g/day. In fact, even at the 95th quantile, fish consumption from the River is still significantly lower than the WDOH recommendation for the majority of fish with an advisory, including the walleye and trout that comprise about 84% of overall consumption.

105. Importantly, I find that there is no statistically significant difference in fish consumption between individuals who are aware of the advisories and those who are not. This finding suggests that fish consumption advisories are not depressing rates of consumption of fish from the Spokane River. Rather, most anglers choose to consume low rates of Spokane River-sources fish for other reasons such as dietary preferences or the abundance of substitute fishing sites in eastern Washington.

106. I reserve the right to amend my analysis should more information become available to me.

David Sunding, Ph.D.
November 15, 2019

APPENDIX A: CURRICULUM VITAE OF DAVID SUNDING

Dr. David L. Sunding is the Thomas J. Graff Professor in the College of Natural Resources at the University of California, Berkeley. His teaching and research centers on microeconomics, applied econometrics, environmental and resource economics, and law and economics. He has published more than 100 articles, and has served two terms as the chair of his department.

Professor Sunding served as a senior economist on the President's Council of Economic Advisers in the Clinton Administration, where he had responsibility for the areas of environment, natural resources, agriculture, and energy. He has testified before Congress on numerous occasions and has served on panels of the National Academy of Sciences and the EPA's Science Advisory Board.

In his role as a principal of The Brattle Group, Professor Sunding is a member of the firm's litigation practice. He has worked as an expert in cases involving damages, penalties, competition, regulation, and product liability in industries including oil and gas, utilities, chemicals, mining, agriculture, and manufacturing. He has served as a consultant and advisor to the U.S. Department of Justice and the State of California.

AREAS OF EXPERTISE

- Damages
- Environment
- Natural Resources
- Competition
- Product Liability
- Law and Economics
- Survey Research
- Econometrics

INDUSTRY EXPERTISE

- Agriculture
- Oil and Gas
- Mining
- Chemicals
- Water
- Food Markets
- Manufacturing
- Utilities

PROFESSIONAL WORK EXPERIENCE

The Brattle Group

2011–Present	Principal, Litigation Practice, San Francisco, CA

University of California, Berkeley

2009–Present	Thomas J. Graff Professor in the College of Natural Resources
2013–Present	Department Chair
2013–Present	Energy and Resources Group, Affiliated Faculty
2005–2013	Berkeley Water Center, Director
2002–Present	Professor
2000–2002	Associate Professor (with tenure)
1997–2004	Center for Sustainable Resource Development, Director
1997–2014	College of Natural Resources, Specialist
1992–1996	Visiting Assistant Professor

Stanford University

2010–2011	Woods Institute of the Environment, Visiting Professor

The White House

1996–1997	President's Council of Economic Advisers, Senior Economist,

Boston College

1989–1992	Department of Economics and School of Law, Assistant Professor,

U.S. Department of State

1985	Freetown, Sierra Leone

EDUCATION

University of California, Berkeley

1989	Ph.D., Agricultural and Resource Economics

University of California, Los Angeles

1986	M.A., African Area Studies

Claremont McKenna College

1983	B.A., Economics

CONSULTING EXPERIENCE

- Filed expert report concerning the injury to the State of Texas resulting from New Mexico's non-compliance with the Rio Grande Compact. Texas v. New Mexico and Colorado, No. 141 Orig., U.S. Supreme Court (State of Texas).

- Filed written testimony and testified at deposition regarding public nuisance from PCBs in sediments in San Diego Bay. San Diego Unified Port District and City of San Diego v. Monsanto Company, Solutia, Inc. and Pharmacia Corporation, CL-05285, U.S. District Court for the Southern District of California (Monsanto Company).

- Filed testimony with the Federal Energy Regulatory Commission relating to the economic impacts of license conditions imposed on the Don Pedro Project. Don Pedro Relicensing Project, No. 2299, Federal Energy Regulatory Commission, 2013 (San Francisco Public Utilities Commission).

- Testified in deposition and at trial on product liability for the 1,3-D class of soil fumigants in a case involving groundwater contamination. City of Atwater v. Shell Oil and Dow Chemical, No. SCVSS-120627, Fresno County Superior Court (Shell Oil, Western Farm Service, Dow Chemical and Dow Agrosciences).

- Filed three reports, gave two depositions and testified in open court on matters relating to class certification in a case concerning an alleged price fixing conspiracy in the packaged seafood products industry. In Re. Packaged Seafood Products Antitrust Litigation, MDL No. 15-MD-2670 JLS MDD, U.S. District Court for the Southern District of California (Class of End Payer Plaintiffs).

- Authored a report and testified in deposition in a matter regarding the economic impacts of a stop sale order issued against products containing the pesticide PCNB. American Vanguard v. United States, No. 16-694 C, U.S. Court of Federal Claims (U.S. Department of Justice).

- Testified in a matter concerning alleged collusion among haulers and recyclers in the market for reformulated and recycled architectural paint products. GreenCycle Paint, Inc. v. PaintCare, Inc., et al., No. 3:15-cv-04059-MEJ, U.S. District Court for the Northern District of California.

- Working on behalf of the major producer of asphalt in Southern California, authored a study concerning the potential anticompetitive effects of Marathon Petroleum's control of asphalt terminals through its proposed acquisition of Andeavor (World Oil).

- Analyzed the allocation of costs for construction and operating a regional wastewater treatment facility *City of Riverside v. Rubidoux Community Services District, et al.*, Case No. CIV DS 1310520, San Bernardino County Superior Court, 2015 (Rubidoux Community Service District).
- Developed and implemented a model of the cost of relicensing proposals for the Don Pedro Project under consideration by the Federal Energy Regulatory Commission and the State of California. Don Pedro Relicensing Project, No. 2299, Federal Energy Regulatory Commission, 2013 (San Francisco Public Utilities Commission).
- Developed econometric and microeconomic models to measure the natural resource damages resulting from PFC contamination of groundwater and surface water resources in the eastern Minneapolis-St. Paul metro region. Assessed the human health impacts of exposure to PFCs in drinking water. Conducted surveys of homeowners and anglers in the State of Minnesota. *State of Minnesota, et al. v. 3M Company*, No. 27-CV-10-28862, Hennepin County District Court, 2010 (State of Minnesota).
- Authored testimony concerning the proper penalty to be paid by a manufacturing company as a result of alleged violations of its permit to discharge wastewater into the Columbia River, *Columbia Riverkeeper v. Sandvik Special Metals*, No. 4:15-CV-05118-LRS, U.S. District Court, Eastern District of Washington, 2015 (Sandvik Special Metals).
- Examined the economic impacts of a cap on Georgia's consumptive use of the Flint and Chattachoochee Rivers for urban and agricultural water supplies. Assessed public support for various policy interventions to enhance instream flows using a survey of households in Florida, Georgia and Alabama. *Florida v. Georgia*, No. 142 Original, U.S. Supreme Court, 2013 (State of Florida).
- Conducted an econometric analysis of defendant's sales efforts as part of a breach of contract claim. Conducted other analyses concerning equipment leasing, prices paid for certain commodities, allocation of joint costs, and other issues. Testified on several occasions before the arbitration panel. *The Paramount Group, et al. v. SP Group, et al.*, Commercial Arbitration Tribunal, 2016 (Paramount Group).
- Developed an econometric reduced-form price equation for the fluid milk industry in 16 states to quantify the price increase resulting from a program to cull dairy cows. *Edwards, et al. v. National Milk Producers Federation, et al.*, U.S. District Court for the Northern District of California, No. 3:11-CV-04766-JSW [consolidated with 11-CV-04791-JSW and 11-CV-05253-JSW], 2015 (Class of indirect purchasers).
- Developed an econometric model to measure the diminution in value of a large coastal property in the State of Louisiana as a result of oil contamination (ConocoPhilips).
- On behalf of a mining company developing a copper-nickel deposit in northern Minnesota, assessed a proposed valuation of ecosystem services of the St. Louis River watershed in Minnesota (PolyMet Mining).

- Testified regarding the penalty to be paid by an investor-owned utility resulting from alleged violations of the Clean Water Act. *Congaree Riverkeeper v. Carolina Water Service, Inc.*, No. 3:15-CV-00194-MBS, U.S. District Court for the District of South Carolina, Columbia Division, 2016 (Carolina Water Service).
- Submitted a declaration as part of an amicus brief filed with the U.S. Supreme Court concerning the immediate economic consequences of environmental permitting requirements. *U.S. Army Corps of Engineers v. Hawkes Co., Inc.*, No. 15-290, U.S. Supreme Court, 2016 (Cargill, The Irvine Company, Port Blakely Companies, Utility Water Act Group, et al.).
- Chief economic adviser to the State of California for the $15-billion Bay Delta Conservation Plan/California WaterFix project (California Natural Resources Agency).
- Developed a conceptual model and conducted an empirical analysis of emissions leakage potential associated with California's implementation of AB32. Results of the analysis used in part to make the State's initial direct allocation of emissions credits under its cap and trade program (California Air Resources Board).
- Testimony regarding the proper civil penalty to be paid by a non-operating investor in an offshore oil and gas well. *U.S. v. BP Exploration & Prod. Co.*, No. 2:10-cv-04536, U.S. District Court for the Eastern District of Louisiana, 2015 (Anadarko Petroleum).
- Testified regarding the measurement of natural resource damages associated with air emissions and groundwater contamination from a landfill site in the St. Louis, MO region that was undergoing a subsurface reaction. *State of Missouri v. Republic Services, Inc., Allied Services, Inc., and Bridgeton Landfill, LLC*, Case No. 13SL-CC01088, Circuit Court of St. Louis County, State of Missouri, 2015 (Republic Services).
- Working on behalf of a group of trade associations, assessed the federal government's economic analysis of the Waters of the United States Rule, and offered guidance on how to improve the analysis. Briefed Congress and OMB. (American Petroleum Institute, Farm Bureau, National Association of Home Builders, Utility Water Act Group, others).
- Determined just compensation for takings and presented testimony. *Klamath Irrigation District v. United States*, No. 01-591 L, U.S. Court of Federal Claims, 2014 (U.S. Department of Justice).
- Testified on behalf of a public agency regarding whether certain charges violated California's Proposition 218. *City of Cerritos, et al. v. Water Replenishment District of Southern California*, No. BS128136, Los Angeles County Superior Court, 2014 (Water Replenishment District of Southern California).

- Conducted a fish consumption survey and other empirical analyses to quantify the public health benefits of proposed remediation alternatives for the Portland Harbor Superfund site (Schnitzer Steel, Vigor Industrial, Greenbrier Companies).
- On behalf of the largest oil recycler in California, conducted an analysis of public policies to encourage collection and re-use of lubricating oil. Demonstrated that California's existing deposit-refund system for motor oil is highly beneficial to the industry and the public (Demenno/Kerdoon).
- Conceived and implemented an integrated, econometric land use-water demand forecasting model of Southern California. Results form the basis of MWD's 2015 Integrated Resources Plan (Metropolitan Water District).
- Valued certain land and farming assets held by debtor and developed a plan for optimal disposal of inventory. In re Cocopah Nurseries of Arizona Inc., 12-15292, U.S. Bankruptcy Court for the District of Arizona, 2013 (Wells Fargo).
- Testified regarding the foreseeable economic consequences of several operating requirements proposed by FERC. Don Pedro Relicensing Project, No. 2299, Federal Energy Regulatory Commission, 2013. (San Francisco Public Utilities Commission).
- Testified on damages and related issues in a breach of contract matter. *Stockton East Water District and Central San Joaquin Water District v. United States*, No. 04-541L, U.S. Court of Federal Claims, 2012. (U.S. Department of Justice).
- Authored an economic study of the incentive effects of EPA's ex post veto authority under the Clean Water Act. *Mingo Logan Coal Company v. United States Environmental Protection Agency*, No. 1:10-cv-00541, U.S. District Court for the District of Columbia, 2012 (Arch Coal).
- Prepared testimony on the consequences of invalidating a water storage project in Kern County. *Central Delta Water Agency, et al. v. California Department of Water Resources, et al.*, No. 34-2010-80000561, Sacramento County Superior Court, 2012 (Kern Water Bank Authority).
- Testified regarding damages and unjust enrichment resulting from the State of Nebraska's alleged violation of the Republican River Compact. *Kansas v. Nebraska*, No. 126 Original, U.S. Supreme Court, 2012 (State of Nebraska).
- Testified on behalf of an investor-owned utility regarding alleged violations of the California Public Utilities Code. *Primex LLC v. Roll International Corporation*, No. 10CECG01114, Fresno County Superior Court, 2012 (Westside Mutual).
- Examined the economic benefits of excluding certain commercial forestlands and areas slated for future residential development from federal critical habitat for the Canada lynx. Report filed with U.S. Department of the Interior (Plum Creek Timber).

- Testified on behalf of the State of Texas regarding the economic impacts on the electricity and water sectors of endangered species-related modifications to the State's water permitting system. *The Aransas Project v. Shaw, et al.*, No. 2:10-cv-00075, U.S. District Court for the Southern District of Texas, 2011 (Guadalupe-Blanco River Authority).
- Authored testimony on the economic impacts of outflow criteria to protect salmonid species in the Sacramento-San Joaquin Delta. *San Luis & Delta-Mendota Water Authority v. Locke, et al.*, No. 1:09-cv-1053, U.S. District Court for the Eastern District of California, 2011 (San Luis & Delta-Mendota Water Authority).
- Assessed the economic costs and benefits of proposed designation of critical habitat for the polar bear. Analysis focused on impacts to oil and gas exploration and production on the North Slope of Alaska, and on the prevention of accidental discharges of hydrocarbons in areas of critical habitat (ExxonMobil).
- Developed testimony regarding damages from breach of contract. *Casitas Municipal Water District v. United States*, No. 05-168L, U.S. Court of Federal Claims, 2010. (U.S. Department of Justice).
- Assessed the allocation of economic benefits of a proposed set of amendments to a groundwater adjudication in the Los Angeles Basin. *Central Basin Municipal Water District, et al. v. Water Replenishment District of Southern California*, No. BS132202, Los Angeles County Superior Court, 2010 (Water Replenishment District of Southern California).
- Assessed the benefits to ratepayers and the public of a proposed desalination project in Monterey County. California Public Utilities Commission, Application of California American Water Company (U 210 W) for a Certificate of Convenience and Necessity to Construct and Operate its Coastal Water Supply Project to Resolve the Long-Term Water Supply Deficit in its Monterey District and to Recover all Present and Future Costs in Connection Therewith in Rates, Application 04009-019, 2009. (Marina Coast Water District)
- Testified in a product liability case involving the chemical TCP. Research concerned a variety of issues including the demand for the products at issue, the distribution of benefits from use of the products, and the role of public institutions in developing and promoting the products. *City of Redlands v. Shell Oil Company, et al.*, No. SCVSS 120627, San Bernardino County Superior Court, 2009 (Shell Chemical and Dow Chemical).
- Developed testimony on groundwater allocation and the prevention of seawater intrusion on the Monterey Peninsula. *California-American Water v. City of Seaside, et al., and Monterey Peninsula Water Management District*, No. H034335, Monterey County Superior Court, 2010 (Monterey Peninsula Water Management District).

- Conducted an economic analysis of remediation costs and benefits to public health and the environment of proposed water quality and sediment standards for PCBs and Mercury (General Electric).
- Measured economic impacts of environmental permitting requirements affecting two toll road projects in Southern California (Transportation Corridor Agencies).
- Testimony regarding the civil penalty to be paid by a major food processing company for alleged violations of its wastewater discharge permit. California Regional Water Quality Control Board, Central Valley Region, ACL Complaint No. R5-2005-0501, 2010 (Hilmar Cheese).
- Developed an approach for measuring the economic costs of critical habitat designation. Applied the method to the case of critical habitat for the red-legged frog and the coastal California gnatcatcher (California Building Industry Association).
- Member of the team negotiating the Quantification Settlement Agreement for the Colorado River. The Revised Fourth Amendment to the QSA resulted in the Imperial Irrigation District – San Diego water transfer, the largest water transfer arrangement in U.S. history (San Diego County Water Authority).

PUBLICATIONS

Working Papers

- *Incentive Effects and the Certainty of Environmental Permits: An Economic Analysis of* Arch Coal. With Steve Hamilton.
- *Multimarket Effects of Environmental Regulations*. With Stephen Hamilton.
- *Regulation by Permit*. With Stephen Hamilton and Cyrus Ramezani.
- *Economics of Penalties for Environmental Violations*. With Stephen Hamilton.
- *A Markov Model of Supply Response to Resource Availability*. With David McLaughlin and Steven Buck.
- *Strategic Behavior in an Environmental Market*. With Charlie Gibbons and Dina Gorenshteyn.

Publications

- "Economic Impacts of Critical Habitat Designation: Evidence from the Market for Vacant Land." With Maximillian Auffhammer and Maya Oren. *Land Economics*, in press, 2019.

- "Forecasting Urban Water Demand: Rethinking Model Selection." With Hilary Soldati, Maximillian Auffhammer and Steven Buck. *Water Resources Research*, in press, 2019.
- "Welfare Consequences of the California Drought Mandate." With Steven Buck and Mehdi Nemati. *Applied Economic Perspectives and Policy*, in press, 2019.
- "The Value of Urban Water Supply Reliability." With Maximillian Auffhammer, Steven Buck, and Stephen Hamilton. *Journal of the Association of Environmental and Resource Economists* (2016), DOI: 10.1086/687761.
- "Optimal Recycling Policy for Used Lubricating Oil: The Case of California's Used Oil Management Policy." With Stephen Hamilton. *Environmental and Resource Economics* (2015), DOI: 10.1007/s10640-014-9812-x.
- "The Impact of Water Price Uncertainty on the Adoption of Precision Irrigation Systems." With Karina Schoengold. *Agricultural Economics* (2014), DOI: 10.1111/agec.12118.
- "Potential Economic Impacts of Environmental Flows Following a Potential Listing of Endangered Texas Freshwater Mussels," With Brad Wolaver, Cassandra Cook, Stephen Hamilton, Bridget Scanlon, Michael Young, Xianli Xu, and Robert Reedy. *Journal of the American Water Resources Association* (2014), DOI: 10.1111/jawr.12171.
- "Land Markets and the Value of Water Supply: Hedonic Analysis using Panel Data." With Steven Buck and Maximillian Auffhammer. *American Journal of Agricultural Economics* 96(2014): 953-969.
- "Conserving Endangered Species through Regulation of Urban Development: The Case of California Vernal Pools." With Jonathan Terhorst. *Land Economics* 90(2014): 290-305.
- "Environmental Policy with Collective Waste Disposal." With Stephen Hamilton, Thomas Sproul, and David Zilberman. *Journal of Environmental Economics and Management* 66(2013): 337-346.
- *Water and the California Economy*. With Ellen Hanak, Jay Lund, Barton Thompson, et al. Public Policy Institute of California, 2012.
- "Hedonic Analysis with Locally Weighted Regression: Measuring the Shadow Value of Housing Regulation in Southern California." With Aaron Swoboda. *Regional Science and Urban Economics* 40(2011): 550-573.
- "On The Spatial Nature of the Groundwater Pumping Externality." With Nicholas Brozovic and David Zilberman. *Resource and Energy Economics* 32(2010): 154-164.
- *Economic Impacts of Water Supply Disruptions Caused by Seismic Events in the Bay-Delta Estuary*. September 2010.

- "Improving Groundwater Management to Cope with Reduced Surface Water Imports: The Case of Los Angeles County." With Steve Hamilton and Newsha Ajami. In A. Findikakis, ed., *Groundwater Management Practices*, Leiden: CRC Press, 2010.
- *Economic Impacts of Residential Water Shortages in California*. With Steve Hamilton. April 2010.
- "The Economics of Federal Land Use Controls." *Rebuilding the Ark: Strategies for Reforming the Endangered Species Act*. Jonathan Adler, ed., Washington, DC: AEI-Brookings Joint Center for Regulation, 2009.
- *Economic Impacts of Flow Requirements for Delta-Dependent Species*. With Newsha Ajami, David Mitchell, Steve Hatchett, and David Zilberman. December 2008.
- *The Economics of Stormwater Regulation*. June 2008.
- *Strategies to Reduce the Economic Impacts of Drought-Induced Water Shortage in the San Francisco Bay Area*. April 2007.
- "Sustainable Management of Water Resources under Hydrologic Uncertainty." With Newsha Ajami and George Hornberger. *Water Resources Research* 44(2008): W11406, doi: 10.1029/2007WR006736.
- "Estimating Business and Residential Water Supply Interruption Losses from Catastrophic Events." With Nicholas Brozovic and David Zilberman. *Water Resources Research* 43(2007): 418-428.
- *Management of Saline Wastewater Discharges in the San Joaquin Valley*. Report to the Central Valley Regional Water Quality Control Board. With Yoram Rubin, Gretchen Miller, Pascual Benito, Ulrich Meyer, Michael Kavanaugh, Todd Anderson, Mark Berkman, David Zilberman, and Steve Hamilton. September 2007.
- "Consideration of Economics under the California Porter-Cologne Act." With David Zilberman. *Hastings West-Northwest Journal of Environmental Law & Policy* (2007): 73-116.
- "Water Markets and Trading." With Howard Chong. *Annual Review of Environment and Resources* 31(2006): 239-264.
- "Panel Estimation of an Agricultural Water Demand Function." With Karina Schoengold and Georgina Moreno. *Water Resources Research* 42(2006): 411-421.
- "Fat Taxes and Thin Subsidies: Prices, Diet and Health Outcomes." With Sean Cash and David Zilberman. *Acta Agriculturae Scand. C* 2(2006): 167-174.
- "Economic Impacts." *The Endangered Species Act at Thirty*. M. Scott, D. Goble, and F. Davis, eds. Washington, DC: Island Press, 2006.

- "The Economics of Environmental Regulation of Housing Development." *Housing and Society* 32(2005): 23-38.
- "Joint Estimation of Technology Adoption and Land Allocation with Implications for the Design of Conservation Policy." With Georgina Moreno. *American Journal of Agricultural Economics* 87(2005): 1009-1019.
- "Factor Price Risk and the Adoption of Conservation Technology." With Georgina Moreno. *Frontiers in Water Resource Economics*. D. Berga and R. Goetz, eds. New York: Springer-Verlag, 2005.
- "Optimal Management of Groundwater over Space and Time." With Nicholas Brozovic and David Zilberman. *Frontiers in Water Resource Economics*. D. Berga and R. Goetz, eds. New York: Springer-Verlag, 2005.
- "Response to 'Environmental Regulation and the Housing Market: A Review of the Literature' by Katherine Kiel." Cityscapes 8(2005): 277-282.
- A Guide to Consideration of Economics under the California Porter-Cologne Act. With David Zilberman. March 2005.
- "Water Allocation and Water Market Activity in California." With Richard Howitt. California Agriculture: Dimensions and Trends. Jerome Siebert, ed. Giannini Foundation, 2004.
- "The Economics of Climate Change in Agriculture." With Xuemei Liu, David Roland-Holst and David Zilberman. Mitigation and Adaptation Strategies for Global Change 9(2004): 365-382.
- "Wetlands Regulation … An Opening for Meaningful Reform?" Regulation 26(2003): 30-35.
- "Government Regulation of Product Quality in Markets with Differentiated Products: Looking to Economic Theory." American Journal of Agricultural Economics 85(2003): 720-724.
- Fiscal Costs and Economic Impacts of Recovering the Coho Salmon in California. With Alix Peterson Zwane. California Department of Fish and Game. October 2003.
- Economic Impacts of Critical Habitat Designation for the Coastal California Gnatcatcher. July 2003.
- The Economic Impacts of Critical Habitat Designation: Framework and Application to the Case of California Vernal Pools. With Aaron Swoboda and David Zilberman. January 2003.
- Non-Federal and Non-Regulatory Approaches to Wetland Conservation: A Post-SWANCC Evaluation of Conservation Alternatives. National Center for Housing and the Environment. December 2002.

- Economic Impacts of Earthquake-Induced Water Supply Shortages in the San Francisco Bay Area. With Nicholas Brozovic and David Zilberman. Bay Area Economic Forum. October 2002.
- Economic Impacts of Organophosphate Use in California Agriculture, Parts 1 and 2. With Mark Metcalfe, Bruce McWilliams, Brent Hueth, Robert Van Steenwyk and David Zilberman. California Department of Food and Agriculture. February 2002.
- "The Economics of Environmental Regulation by Licensing: Observations on Recent Changes to the Federal Wetland Permitting Program." With David Zilberman. *Natural Resources Journal* 42(Winter 2002): 59-90.
    - Cited in the U.S. Supreme Court's plurality and dissenting opinions in the consolidated cases of *Rapanos v. United States* and *Carabell v. United States*.
- "Trading Patterns in an Agricultural Water Market." With Nicholas Brozovic and Janis Carey. *Water Resources Update* (2002): 3-16.
- "Public Goods and the Value of Product Quality Regulations: The Case of Food Safety." With Stephen Hamilton and David Zilberman. *Journal of Public Economics* 87(2003): 799-817.
- "Regulating Pollution with Endogenous Monitoring." With Katrin Millock and David Zilberman. *Journal of Environmental Economics and Management* 44(2002): 221-241.
- "Transactions Costs and Trading Behavior in an Immature Water Market." With Janis Carey and David Zilberman. *Environment and Development Economics* 7(2002): 733-750.
- "Measuring the Costs of Reallocating Water from Agriculture: A Multi-Model Approach." With David Zilberman, Richard Howitt, Ariel Dinar, and Neal MacDougall. *Natural Resource Modeling* 15(Summer 2002): 201-225.
- "Voluntary Development Restrictions and the Cost of Habitat Preservation." With Sabrina Lovell. *Real Estate Economics* 29(March 2001): 191–206.
- "Emerging Markets in Water: A Comparative Institutional Analysis of the Central Valley and Colorado-Big Thompson Projects." With Janis Carey. *Natural Resources Journal* 41(2001): 283–328.
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- "A Comparison of Policies to Reduce Pesticide Poisoning Combining Economic and Toxicological Data." With Joshua Zivin. In: Joe Moffitt (ed.). *Advances in the Economics of Environmental Resources: Volume 4*. Greenwich: JAI Press, 2001.

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- "The Agricultural Innovation Process: Research and Technology Adoption in a Changing Agricultural Sector." With David Zilberman. In: Bruce Gardner and Gordon Rausser (eds.), *Handbook of Agricultural and Resource Economics*. Amsterdam: North Holland, 2001, 207-261.
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- *A Proposal for Management of the Confined Aquifer in the Western San Joaquin Valley*. With David Purkey. July 2000.
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- "Insect Population Dynamics, Pesticide Use and Farmworker Health." With Joshua Zivin. *American Journal of Agricultural Economics* 82(August 2000): 527–540.
    - Winner of the AAEA Outstanding Journal Article Award.
- "Product Liability, Entry Incentives and Market Structure." With Stephen Hamilton. *International Review of Law and Economics* 20(September 2000): 269–283.
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- "Methyl Iodide as an Alternative to Methyl Bromide." With Brent Hueth, Bruce McWilliams, and David Zilberman. *Review of Agricultural Economics* (Spring/Summer 2000): 43–54.
- "Using Water Markets to Improve Environmental Quality: Two Innovative Programs in Nevada." With Sabrina Ise Lovell and Katrin Millock. *Journal of Soil and Water Conservation* 55(First Quarter 2000): 19–26.
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- *Costs of Implementing the Food Quality Protection Act of 1996 on California Agriculture*. With Bruce McWilliams, Yuria Tanimichi and David Zilberman. September 1999.
- *Economic Impact of Restricting Use of Compound 1080 in California's Intermountain Region*. With Brent Hueth and Michelle McGregor. California Department of Pesticide Regulation. April 1999.
- *Downstream Economic Impacts of Reducing Federal Water Subsidies: The Case of Alfalfa and Dairy.* With Georgina Moreno. Natural Resources Defense Council. August 1998.
- *Economic Importance of Organophosphates in California Agriculture*. With Brent Hueth, Grazyna Michalska, and David Zilberman. California Department of Food and Agriculture. August 1998.
- *An Environmentally Optimal Alternative for the San Francisco Bay-Delta*. With John Cain, David Fullerton, David Purkey, and Greg Thomas. Natural Heritage Institute. July 1998.
- *Water Trading and Environmental Quality in the Western United States.* With David Zilberman. U.S. Environmental; Protection Agency. April 1998.
- *Impact of Endangered Species Legislation on California Agriculture*. With David Zilberman, Jerome B. Siebert, Joshua Zivin, Sabrina Isé, and Brent Hueth. California Resources Agency. January 1998.
- *Economic Impact on California Agriculture of Banning Methyl Bromide Use*. With Bruce McWilliams, Brent Hueth, Lori Lynch, David Zilberman, and Jerome Siebert. California Department of Food and Agriculture. January 1998.
- "Returns to Public Investment in Agriculture with Imperfect Downstream Competition." With Stephen Hamilton. *American Journal of Agricultural Economics* 80(November 1998): 830–838.

- "Reallocating Water from Agriculture to the Environment under a Voluntary Purchase Program." With Sabrina Ise. *Review of Agricultural Economics* 20(Summer 1998): 214–226.
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- "Innovative Approaches to Water Conservation: The Westside Case." Joint U.S. Bureau of Reclamation and the California Department of Water Resources Water Conservation Information Committee. San Diego, CA. August 1998.
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COURSES TAUGHT

- Advanced Topics in Environmental and Resource Economics (Graduate)
- Risk, Technology and the Environment (Graduate)

- Environmental and Resource Economics (Graduate)
- Economics of Water Resources (Undergraduate)
- Natural Resource Economics (Undergraduate)
- Economics of Public Law (UC Berkeley School of Law)
- Environmental Policy (Undergraduate)
- Public Finance (Graduate)
- Microeconomic Theory (Graduate and Undergraduate, UC Berkeley and Boston College)
- Law and Economics (Boston College School of Law)

ACADEMIC SEMINARS

University of Arizona, Boston College, Boston University, UC Berkeley, UC Davis, UC Irvine, UCLA, UC Riverside, UC Santa Barbara, University of Colorado, Harvard University, Hebrew University of Jerusalem, Imperial College London, Johns Hopkins University, Kansas State University, University of Maryland, Massachusetts Institute of Technology, University of Massachusetts, Montana State University, Ohio State University, University of Pennsylvania, Purdue University, Stanford University, U.S. Department of Agriculture, U.S. Department of the Interior, U.S. Environmental Protection Agency, U.S. Department of Housing and Urban Development, University of Wisconsin, University of Wyoming.

PROFESSIONAL ASSOCIATIONS

- American Economic Association
- American Law and Economics Association
- Association of Environmental and Resource Economists
- Econometric Society

APPENDIX B: DOCUMENTS RELIED UPON

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APPENDIX C: TECHNICAL APPENDIX ON ESTIMATES OF FISH CONSUMPTION RATES

1. In this appendix, I provide additional details on the construction of my fish consumption rate estimates. The R script *estimate_fcr.R* contains the function *fcr_quantile()* that I have written to construct my fish consumption rate estimates.

2. Using the Robinson dataset, I classify all respondents into one of six behavioral categories based on their responses to questions 5, 6 and 34:

    a. Respondents who **visit** and **fish** and do **consume fish** from the Spokane River

    b. Respondents who **visit** and **fish** but **do not consume fish** from the River

    c. Respondents who **visit** and do **not fish** and but do **consume fish** from the River

    d. Respondents who **visit** and do **not fish** and **do not consume fish** from the River

    e. Respondents who **do not visit** the River but do **consume fish** from it

    f. Respondents who **do not visit** and **do not consume fish** from the River

3. Using the *mlogit* package in R, I estimate the following multinomial logit model on all valid observations from the Robinson dataset:

$$mlogit(interactions \sim 1 \mid age\_factor + sex + county, c)$$

4. where the dependent variable is the behavioral category of each individual, and the control variables are dummy variables for the following covariates: sex (male vs. female), age (18-30, 31-50, 51-65, 66+) and county (Spokane vs. Stevens vs. Lincoln). For each of the 24 permutations of the demographic characteristics described above, I then use the *predict()* function to predict the probability a respondent chooses each of the six behavioral categories (or equivalently, the share of all respondents who choose each behavioral category). I calculate the number of individuals who engage in each activity within each demographic group by multiplying the predicted share of individuals who engage in each activity by the total population of that demographic group.

5. In parts of my analysis, I estimate rates of child-sharing or awareness of fish advisories; similar to above, I estimate a similar logit model to predict the number of individuals in the population who engage in these behaviors.

6. Next, I turn to the IEc Dataset. For each response, I calculate a fish consumption rate in grams per day using the method described in Section IV.B. I classify all responses in the IEc dataset into the same behavioral categories as I do for the Robinson based on responses to questions D1 and D2. Since the IEc survey is an intercept survey, mechanically, there no responses in the dataset from individuals who 'do not visit' the site.

7. For each of the 24 permutations of demographic characteristics, I estimate the empirical distribution of the rate of fish consumption, specifically I estimate weighted quantiles of the fish consumption rate for every percentile point between zero and one (i.e., 0.00, 0.01, 0.02, 0.03, … 0.98, 0.99, 1.00), where quantiles are weighted by the person weights calculated by IEc in their survey.

8. I merge the quantile estimates of fish consumption rates calculated from IEc with the estimates of the population of fish consumers calculated from the Robinson survey. Within each demographic group, I estimate the population of fish consumers at each quantile of fish consumption by dividing the population from the Robinson survey across each quantile of fish consumption. Thus for each of 24 demographic groups (permutations of sex, age and county), I have calculated the number for individuals in each of 6 behavioral categories (visits, fishes and consumes) and for those who consume I have calculated the number of individuals at 101 quantiles of fish consumption, and the corresponding rate of fish consumption at that quantile. The product of these groups amount to a total of 14544 estimates of population and fish consumption rate.

9. To estimate population fish consumption rates, I calculate weighted quantiles of fish consumption across these 14,544 fish consumption estimates, weighting the responses by the estimated population in each group. I produce these quantile estimates using the *rq()* function in the *quantreg* package. I produce mean fish consumption rate estimates using the *weighted.mean()* function in the *stats* package.

10. I calculate the number of individuals consuming more than one fish meal per week (equivalent to 32.5 g/day based on an 8 oz portion size) by calculating the number of individuals in quantiles whose consumption rate exceeds this level.

11. I construct confidence intervals for all of my estimates (specifically visitation, angling and consumer populations, as well as fish consumption rates) using a bootstrap methodology. In the bootstrap method, many alternative datasets are constructed by randomly

resampling the underlying data with replacement many times. Alternative estimates are constructed from these alternative datasets. Quantiles of the distribution of the alternative estimates (usually the 2.5th and 97.5th percentile) are used to produce a 95% confidence interval. Bootstrap is a commonly used method estimate to estimate confidence intervals for complex estimates when estimators based on statistical theory are not available. To estimate my bootstrap, I recursively call the *fcr_quantile()* function that I use to estimate fish consumption quantiles. I estimate 2001 bootstrap iterations to construct my confidence intervals. In each bootstrap iteration, I resample all observations from both the Robinson and IEc dataset with replacement. I take the 2.5th and 97.5th percentile of the estimates for each variable (local visitor, angler and consumer populations, and weighted mean and quantiles of fish consumption) to construct my confidence intervals.

APPENDIX D: ADDITIONAL TABLES FROM ANALYSIS OF FISH CONSUMPTION RATES

In this appendix, I produce at the requestion of Counsel additional tables reporting the results from my analysis of fish consumption rates along the Spokane River in additional detail. In Appendix Table 1, I report the same estimates of fish consumption rates previously presented in

12. Table 6, except that Appendix Table 1 presents additional quantile estimates to characterize the distribution of fish consumption rates in more detail.

13. In Appendix Table 2, I report the same estimates of fish consumption rates previously presented in Appendix Table 1, except that Appendix Table 2 presents the quantiles of fish consumption rate among only residents of Spokane County, which contains the City of Spokane, rather than of the entire Spokane Region, consisting of all of Spokane, Stevens and Lincoln counties.

14. In Appendix Table 3, I estimate species preference as previously discussed in Table 8, except that I collapse the different species of fish that anglers report consuming into different groups. The primary difference between these two specifications is that in Appendix Table 3, individuals who report consuming "other" fish species in the IEc survey have their responses broken out into groupings of perch, (non-rainbow) trout and other.

15. In Appendix Table 4, I report the same estimates of fish consumption rates by species previously presented in Table 9, except that I present estimates among all resident consumers of Spokane River fish rather than just among resident anglers.

16. In Appendix Table 5, I present additional quantiles of my estimates of the rate of fish consumption among children by resident anglers of the Spokane River.

In Appendix Table 6, I reproduce the estimates of my of quantiles of the fish consumption rate previously presented in

17. Table 6, except that instead of using all responses from the IEc survey, I restrict the data I use to the reaches of the Upper Columbia River that are most relevant to fish consumption on the Spokane River, specifically the Lower section of Lake Roosevelt (Row [2]) and the Spokane River Arm of Lake Roosevelt (Row [3]. When I use the fish consumption rates estimated solely from the Spokane Arm of Lake Roosevelt, my estimates of fish consumption rates are lower than when I use all available data, however, the difference is not statistically significant.

Appendix Table 1: Fish Consumption Rates by Behavior – Additional Quantiles

	All adult residents	Residents who **visit** the Spokane River	Residents who **fish** the Spokane River	Residents who **consume fish** from the Spokane River
N	391,800	319,500	40,000	30,600
% of Population	100.0%	81.5%	10.2%	7.8%
	Fish Consumption Rate (g/day)			
Mean	0.34	0.42	2.16	4.38
1%	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]
5%	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]
10%	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]
15%	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.47]
20%	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.62]
25%	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.47 [0.00, 0.93]
30%	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.93 [0.37, 1.24]
35%	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.93 [0.47, 1.24]
40%	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.93 [0.93, 1.86]
45%	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	1.40 [0.93, 1.96]
50%	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.09]	1.86 [1.10, 2.49]
55%	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.62]	1.86 [1.40, 2.80]
60%	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.93]	2.49 [1.86, 3.71]
65%	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.62 [0.00, 1.40]	2.80 [2.33, 4.19]
70%	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.93 [0.00, 1.86]	3.73 [2.80, 4.66]
75%	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	1.55 [0.50, 2.80]	4.35 [3.11, 6.96]
80%	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	2.33 [1.24, 3.73]	5.59 [4.35, 8.08]
85%	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	3.73 [1.86, 6.21]	7.92 [4.66, 9.52]
90%	0.00 [0.00, 0.00]	0.00 [0.00, 0.93]	6.21 [3.73, 9.32]	10.10 [8.08, 15.53]
95%	0.93 [0.00, 2.36]	1.55 [0.25, 3.11]	10.10 [7.92, 15.53]	16.78 [12.43, 21.75]
99%	8.70 [5.97, 11.18]	9.94 [7.77, 14.55]	24.85 [20.97, 37.28]	38.84 [27.77, 46.60]
Max	233.04	156.59	156.58	156.58

Source and notes:
This table contains additional quantile estimates of the results in

Table 6.
Mean fish consumption rate and quantiles of the fish consumption rate among different subsets of the adult population of three Washington counties, Spokane, Stevens and Lincoln counties, adjacent to the Spokane River. Estimates are calculated based on the population demographics in Table 3 and responses to part D of the Industrial Economics (2013) Upper Columbia River Survey. The model assumes that rates of fish consumption are similar among anglers on the Spokane River as on Lake Roosevelt within each demographic control group. Standard Errors in square brackets are calculated by bootstrap.
[1]: In this column fish consumption rates are calculated among the entire population of Spokane, Lincoln and Stevens Counties.
[2]: In this column, fish consumption rates are calculated among the subset of the population of these counties who visit the Spokane River in a typical year.
[3]: In this column, fish consumption rates are calculated among the subset of the population who fish from the Spokane River.
[4]: In this column, fish consumption rates are calculated among the subset of the population who consume fish from the Spokane River in a typical month.

Appendix Table 2: Fish Consumption Rates by Behavior – Spokane County Only

	All adult residents	Residents who **visit** the Spokane River	Residents who **fish** the Spokane River	Residents who **consume fish** from the Spokane River
N	352,400	284,900	25,800	17,600
% of Population	100.0%	80.8%	7.3%	5.0%
	Fish Consumption Rate (g/day)			
Mean	0.17	0.21	1.21	3.47
1%	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]
5%	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]
10%	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]
15%	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]
20%	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.47]
25%	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.62]
30%	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.47 [0.00, 0.93]
35%	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.62 [0.00, 0.98]
40%	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.93 [0.47, 1.40]
45%	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.93 [0.47, 1.86]
50%	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	1.24 [0.62, 2.33]
55%	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	1.40 [0.93, 2.49]
60%	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.47]	1.86 [0.93, 2.80]
65%	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.93]	2.49 [1.37, 3.80]
70%	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.93]	2.80 [1.86, 4.35]
75%	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.47 [0.00, 1.86]	3.11 [1.86, 4.80]
80%	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.93 [0.00, 2.33]	4.35 [2.75, 8.12]
85%	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	1.40 [0.00, 3.73]	5.83 [3.73, 9.32]
90%	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	2.80 [0.91, 7.95]	9.32 [4.66, 13.19]
95%	0.00 [0.00, 0.93]	0.00 [0.00, 1.86]	8.08 [2.26, 9.99]	15.53 [9.32, 21.75]
99%	4.35 [1.20, 9.32]	4.66 [2.26, 9.39]	18.64 [9.94, 23.35]	30.76 [21.13, 49.71]
Max	152.62	136.70	943.65	164.02

Source and notes:
This table contains similar results on mean fish consumption and quantiles of fish consumption as Appendix Table 1, except, it restricts it's consideration to only the population of Spokane County, in which the City of Spokane is located.
Mean fish consumption rate and quantiles of the fish consumption rate among different subsets of the adult population of Spokane County. Estimates are calculated based on the population demographics in Table 3 and responses to part D of the Industrial Economics (2013) Upper Columbia River Survey. The model assumes that rates of fish consumption are similar among anglers on the Spokane River as on Lake Roosevelt within each demographic control group. Standard Errors in square brackets are calculated by bootstrap.
[1]: In this column fish consumption rates are calculated among the entire population of Spokane, Lincoln and Stevens Counties.
[2]: In this column, fish consumption rates are calculated among the subset of the population of these counties who visit the Spokane River in a typical year.
[3]: In this column, fish consumption rates are calculated among the subset of the population who fish from the Spokane River.
[4]: In this column, fish consumption rates are calculated among the subset of the population who consume fish from the Spokane River in a typical month.

Appendix Table 3: Species Preference (Separating Perch Group)

	Species share	Mean species FCR (g / day)
Walleye group	50.4%	1.09
	[45.1%, 56.3%]	[0.97, 1.22]
Trout group	35.3%	0.76
	[30.0%, 40.0%]	[0.65, 0.86]
Bass group	7.1%	0.15
	[4.4%, 10.4%]	[0.10, 0.22]
Salmon group	6.3%	0.14
	[4.5%, 7.9%]	[0.10, 0.17]
Perch group	0.4%	0.01
	[0.2%, 0.7%]	[0.00, 0.01]
Other	0.6%	0.01
	[0.3%, 1.0%]	[0.01, 0.02]
Total	100%	2.16

Source and notes: This table calculates the average species composition of fish consumed from the Spokane River in three adjacent Washington counties. Estimates are calculated based on the population demographics in Table 3 and responses to part D of the Industrial Economics (2013) Upper Columbia River Survey. Fish are categorized into groups as requested by Counsel. The model assumes that rates of species-specific fish consumption are similar among anglers on the Spokane River as on Lake Roosevelt within each demographic control group. Standard Errors in square brackets are calculated by bootstrap.

Appendix Table 4: Quantiles of Spokane River Fish Consumption by Species among All Resident Consumers

	All	Walleye	Rainbow Trout	Bass	Koknae	Other
Mean	4.38 [3.42, 5.44]	2.03 [1.53, 2.66]	1.71 [1.31, 2.24]	0.33 [0.18, 0.51]	0.32 [0.18, 0.46]	0.07 [0.03, 0.09]
1%	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]
5%	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]
10%	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]
15%	0.00 [0.00, 0.47]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]
20%	0.00 [0.00, 0.62]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]
25%	0.47 [0.00, 0.93]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]
30%	0.93 [0.37, 1.24]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]
35%	0.93 [0.47, 1.24]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]
40%	0.93 [0.93, 1.86]	0.00 [0.00, 0.47]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]
45%	1.40 [0.93, 1.96]	0.00 [0.00, 0.62]	0.00 [0.00, 0.47]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]
50%	1.86 [1.10, 2.49]	0.47 [0.00, 0.93]	0.00 [0.00, 0.93]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]
55%	1.86 [1.40, 2.80]	0.78 [0.31, 0.93]	0.47 [0.00, 1.24]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]
60%	2.49 [1.86, 3.71]	0.93 [0.47, 1.24]	0.93 [0.30, 1.40]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]
65%	2.80 [2.33, 4.19]	0.93 [0.91, 1.41]	0.93 [0.62, 1.86]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]
70%	3.73 [2.80, 4.66]	1.24 [0.93, 1.86]	1.40 [0.93, 2.33]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]
75%	4.35 [3.11, 6.96]	1.86 [1.20, 2.33]	1.86 [1.24, 2.80]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]
80%	5.59 [4.35, 8.08]	1.86 [1.40, 3.73]	2.49 [1.85, 3.11]	0.00 [0.00, 0.00]	0.00 [0.00, 0.31]	0.00 [0.00, 0.00]
85%	7.92 [4.66, 9.52]	3.11 [1.86, 4.85]	3.11 [2.33, 4.66]	0.00 [0.00, 0.62]	0.00 [0.00, 1.24]	0.00 [0.00, 0.00]
90%	10.10 [8.08, 15.53]	4.66 [3.11, 9.32]	4.66 [3.11, 7.46]	0.62 [0.40, 0.95]	0.93 [0.00, 1.43]	0.00 [0.00, 0.00]
95%	16.78 [12.43, 21.75]	9.94 [7.46, 15.53]	7.77 [5.56, 9.32]	1.24 [0.62, 2.33]	1.86 [1.18, 3.11]	0.00 [0.00, 0.62]
99%	38.84 [27.77, 46.60]	22.37 [15.53, 27.96]	15.53 [12.43, 23.30]	4.66 [2.49, 13.98]	6.21 [3.73, 9.32]	1.35 [0.78, 1.86]
Max	156.58	381.75	143.06	60.58	111.35	59.80

Source and notes:

This table presents similar quantiles to
Table 8, except calculated among resident consumers in the Spokane Region, rather than just anglers.

Quantiles of fish consumption are calculate among all residents in three Washington counties adjacent to the Spokane River. Estimates are calculated based on the population demographics in Table 3 and responses to part D of the Industrial Economics (2013) Upper Columbia River Survey. Fish are categorized into groups as presented in the original survey. The model assumes that rates of species-specific fish consumption are similar among anglers on the Spokane River as on Lake Roosevelt within each demographic control group. Standard Errors in square brackets are calculated by bootstrap. Fish consumption quantile estimates are projected onto the population demographics reported in Table 3.

Appendix Table 5: Inferred Child Fish Consumption Rate - Additional Quantiles

	All adult residents who fish the Spokane River	Anglers who **share with children**	Inferred rate: **angler's children** who cosume fish
% of Population	10.2% [7.3%, 13.5%]	2.0% [7.3%, 13.5%]	
Mean	2.16	3.22	0.97
1%	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]
5%	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]
10%	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]
15%	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]
20%	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]
25%	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]
30%	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]
35%	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]
40%	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]
45%	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]
50%	0.00 [0.00, 0.09]	0.00 [0.00, 0.00]	0.00 [0.00, 0.00]
55%	0.00 [0.00, 0.62]	0.00 [0.00, 0.93]	0.00 [0.00, 0.28]
60%	0.00 [0.00, 0.93]	0.00 [0.00, 1.24]	0.00 [0.00, 0.37]
65%	0.62 [0.00, 1.40]	0.93 [0.00, 2.80]	0.28 [0.00, 0.84]
70%	0.93 [0.00, 1.86]	1.55 [0.00, 3.26]	0.47 [0.00, 0.98]
75%	1.55 [0.50, 2.80]	3.11 [0.00, 4.22]	0.93 [0.00, 1.27]
80%	2.33 [1.24, 3.73]	4.19 [1.40, 7.92]	1.26 [0.42, 2.38]
85%	3.73 [1.86, 6.21]	6.99 [3.11, 9.94]	2.10 [0.93, 2.98]
90%	6.21 [3.73, 9.32]	9.32 [4.61, 12.43]	2.80 [1.38, 3.73]
95%	10.10 [7.92, 15.53]	14.91 [9.32, 22.03]	4.47 [2.80, 6.61]
99%	24.85 [20.97, 37.28]	37.28 [24.23, 69.08]	11.18 [7.27, 20.72]
Max	156.58	156.58	46.97

Source and notes:
This table contains additional quantile estimates of the results in Table 9
This table calculates the number of adults who share fish with children in three Washington counties adjacent to the Spokane River, as well as the child's mean fish consumption rate and quantiles of the fish consumption rate. The estimates of the number of adults who share their fish with children are calculated from a logit model based on responses to question D10 in the Industrial Economics (2013) Upper Columbia River Survey. These responses are projected onto the population demographics reported in Table 3. Child fish consumption rates are estimated based on a child to adult consumption ratio of 0.3 to 1. These ratios are based on the national NHANES database. This model assumes that rates of fish consumption are similar among anglers on the Spokane River as on Lake Roosevelt within each demographic control group. Standard Errors in square brackets are calculated by bootstrap

Appendix Table 6: Model Estimates Using Only Data from Spokane Arm of Lake Roosevelt

		Fish Consumption Rates among Consumers (g/day)				
			Quantiles			
Sub-Population		Mean	50%	90%	95%	99%
FCR estimate based on **all IEc responses**	[1]	4.38 [3.42, 5.44]	1.86 [1.10, 2.49]	10.10 [8.08, 15.53]	16.78 [12.43, 21.75]	38.84 [27.77, 46.60]
FCR estimate based on **only responses from lower UCR**	[2]	4.41 [2.89, 6.06]	1.24 [0.93, 2.49]	13.67 [7.46, 18.64]	18.64 [9.32, 19.94]	23.61 [19.88, 45.05]
FCR estimate based on **only responses from Spokane Arm of Lake Roosevelt**	[3]	3.26 [1.58, 4.51]	0.93 [0.00, 1.86]	9.32 [3.73, 18.64]	18.64 [4.59, 21.75]	22.84 [12.13, 37.28]

Sources and Notes:

This table calculates the mean fish consumption rate and quantiles of the fish consumption rate among anglers on the Spokane River residing in three Washington. Estimates are calculated based on the population demographics in Table 3 and responses to part D of the Industrial Economics (2013) Upper Columbia River Survey. Each estimate is based on using a different subset of the data from the IEc study. The model assumes that rates of fish consumption are similar among anglers on the Spokane River as on Lake Roosevelt within each demographic control group. Standard Errors in square brackets are calculated by bootstrap.

[1]: In this row fish consumption rates are calculated based on all responses to the IEc study.

[2]: In this row fish consumption rates are calculated based on only responses from fish consumers who fish the lower UCR, a reach which stretches from Grand Coulee Dam to near O Ra Pak En Creek.

[3]: In this row fish consumption rates are calculated based on all responses from fish consumers who fish the Spokane Arm of Lake Roosevelt.